13. Equipment: Equip each metal locker with identification plate and the following unless otherwise indicated:
    a. Single-Tier Units: Shelf, one double-prong ceiling hook, and two single-prong wall hooks.
    b. Double-Tier Units: One double-prong ceiling hook and two single-prong wall hooks.
    c. Triple-Tier **OR** Box, **as directed**, Units: One double-prong ceiling hook.
    d. Coat Rods: As indicated on Drawings **OR** For each compartment of single-tier, double-tier, and triple-tier metal lockers **OR** In lieu of ceiling hook for metal lockers 24 inches (610 mm) high or more **OR** In lieu of ceiling hook for metal lockers 18 inches (457 mm) deep or more, **as directed**.
14. Accessories:
    a. Legs: 6 inches (152 mm) high; formed by extending vertical frame members, or fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; welded to bottom of locker.
        1) Closed Front and End Bases: Fabricated from 0.036-inch (0.91-mm) nominal-thickness steel sheet.
    b. Continuous Zee Base: Fabricated from 0.060-inch (1.52-mm) **OR** 0.075-inch (1.90-mm) **OR** manufacturer's standard thickness, but not less than 0.060-inch (1.52-mm), **as directed**, nominal-thickness steel sheet.
        1) Height: 4 inches (102 mm).
    c. Continuous Sloping Tops: Fabricated from 0.036-inch (0.91-mm) **OR** 0.048-inch (1.21-mm) **OR** manufacturer's standard thickness, but not less than 0.036-inch (0.91-mm), **as directed**, nominal-thickness steel sheet.
        1) Closures: Vertical-end **OR** Hipped-end, **as directed**, type.
        2) Sloping-top corner fillers, mitered.
    d. Individual Sloping Tops: Fabricated from 0.024-inch (0.61-mm) nominal-thickness steel sheet.
    e. Recess Trim: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
    f. Filler Panels: Fabricated from 0.036-inch (0.91-mm) **OR** 0.048-inch (1.21-mm) **OR** manufacturer's standard thickness, but not less than 0.036-inch (0.91-mm), **as directed**, nominal-thickness steel sheet.
    g. Boxed End Panels: Fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet.
    h. Finished End Panels: Fabricated from 0.024-inch (0.61-mm) nominal-thickness steel sheet.
    i. Center Dividers: Fabricated from 0.024-inch (0.61-mm) nominal-thickness steel sheet.
15. Finish: Baked enamel **OR** Powder coat, **as directed**.
    a. Color(s): As selected from manufacturer's full range **OR** Two colors, with door one color and frame and body another color; as selected from manufacturer's full range, **as directed**.

C. Heavy-Duty Metal Lockers
1. Locker Arrangement: Single tier **OR** Double tier **OR** Triple tier **OR** As indicated on Drawings, **as directed**.
2. Material: Cold-rolled steel sheet.
3. Body: Assembled by welding body components together. Fabricate from unperforated steel sheet with thicknesses as follows:
    a. Tops, Bottoms, and Sides: 0.060-inch (1.52-mm) nominal thickness.
    b. Backs: 0.048-inch (1.21-mm) nominal thickness.
    c. Shelves: 0.060-inch (1.52-mm) nominal thickness, with double bend at front and single bend at sides and back.
4. Frames: Channel formed; fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet; lapped and factory welded at corners; with top and bottom main frames factory welded into vertical main frames. Form continuous, integral door strike full height on vertical main frames.
    a. Cross Frames between Tiers: Channel formed and fabricated from same material as main frames; welded to vertical main frames.
5. Doors: One piece; fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; formed into channel shape with double bend at vertical edges and with right-angle single bend at horizontal edges.

a. Reinforcement: Manufacturer's standard reinforcing angles, channels, or stiffeners for doors more than 15 inches (381 mm) wide; welded to inner face of doors.
b. Door Style:
1) Louvered Vents: No fewer than six louver openings at top and bottom for single-tier **OR** three louver openings at top and bottom for double-tier **OR** two louver openings at top and bottom, or three louver openings at top or bottom, for triple-tier, **as directed**, lockers.
2) Security Vents: Manufacturer's standard, stamped horizontal or vertical.
3) Perforated Vents: Manufacturer's standard shape and configuration.

6. Hinges: Welded to door and attached to door frame with no fewer than two factory-installed rivets per hinge that are completely concealed and tamper resistant when door is closed; fabricated to swing 180 degrees; self-closing, **as directed**.
a. Knuckle Hinges: Steel, full loop, five or seven knuckles, tight pin; minimum 2 inches (51 mm) high. Provide no fewer than three hinges for each door more than 42 inches (1067 mm) high.
b. Continuous Hinges: Manufacturer's standard, steel, full height.

7. Recessed Door Handle and Latch: Stainless-steel cup with integral door pull, recessed so locking device does not protrude beyond face of door; pry and vandal resistant.
a. Multipoint Latching: Finger-lift latch control designed for use with built-in combination locks or padlocks; positive automatic latching and prelocking.
1) Latch Hooks: Equip doors 48 inches (1219 mm) and higher with three latch hooks and doors less than 48 inches (1219 mm) high with two latch hooks; fabricated from 0.120-inch (3.04-mm) nominal-thickness steel sheet; welded to full-height door strikes; with resilient silencer on each latch hook.
2) Latching Mechanism: Manufacturer's standard, rattle-free latching mechanism and moving components isolated to prevent metal-to-metal contact, and incorporating a prelocking device that allows locker door to be locked while door is open and then closed without unlocking or damaging lock or latching mechanism.
b. Single-Point Latching: Nonmoving latch hook designed to engage bolt of built-in combination or cylinder lock **OR** with steel padlock loop that projects through recessed cup and is finished to match metal locker body, **as directed**.
1) Latch Hook: Equip each door with one latch hook, fabricated from 0.120-inch (3.04-mm) nominal-thickness steel sheet; welded midway up full-height door strike; with resilient silencer.

8. Combination Padlocks: Key-controlled, three-number dialing combination locks; capable of five combination changes **OR** Provided by Owner, **as directed**.

9. Built-in Combination Locks: Key-controlled, three-number dialing combination locks; capable of at least five combination changes made automatically with a control key.
a. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.

10. Equipment: Equip each metal locker with identification plate and the following unless otherwise indicated:
a. Single-Tier Units: Shelf, one double-prong ceiling hook, and two single-prong wall hooks.
b. Double-Tier Units: One double-prong ceiling hook and two single-prong wall hooks.
c. Triple-Tier Units: One double-prong ceiling hook.
d. Coat Rods: As indicated on Drawings **OR** For each compartment of single-tier, double-tier and triple-tier metal lockers **OR** In lieu of ceiling hook for metal lockers 24 inches (610 mm) high or more **OR** In lieu of ceiling hook for metal lockers 18 inches (457 mm) deep or more.

11. Accessories:
a. Legs: 6 inches (152 mm) high; formed by extending vertical frame members, or fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; welded to bottom of locker.
1) Closed Front and End Bases: Fabricated from 0.036-inch (0.91-mm) nominal-thickness steel sheet.
b. Continuous Zee Base: Fabricated from, 0.060-inch (1.52-mm) **OR** 0.075-inch (1.90-mm) **OR** manufacturer's standard thickness, but not less than 0.060-inch (1.52-mm), **as directed**, nominal-thickness steel sheet.

1) Height: 4 inches (102 mm).

c. Continuous Sloping Tops: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet, with a pitch of approximately 20 degrees.

1) Closures: Vertical-end **OR** Hipped-end, **as directed**, type.

d. Recess Trim: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.

e. Filler Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.

f. Boxed End Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.

12. Finish: Baked enamel **OR** Powder coat, **as directed**.

a. Color(s): As selected from manufacturer's full range **OR** Two colors, with door one color and frame and body another color; as selected from manufacturer's full range, **as directed**.

D. Athletic Metal Lockers

1. Locker Arrangement: Single tier **OR** Double tier **OR** Triple tier **OR** Box **OR** As indicated on Drawings, **as directed**.
2. Material: Cold-rolled **OR** Metallic-coated, **as directed**, steel sheet.
3. Body: Assembled by welding **OR** riveting or bolting, **as directed**, body components together. Fabricate from unperforated steel sheet with thicknesses as follows:
   a. Tops and Bottoms: 0.060-inch (1.52-mm) nominal thickness, with single bend at edges.
   b. Backs: 0.048-inch (1.21-mm) nominal thickness.
   c. Shelves: 0.060-inch (1.52-mm) nominal thickness, with double bend at front and single bend at sides and back.
4. Unperforated Sides: Fabricated from 0.048-inch (1.21-mm) **OR** 0.060-inch (1.52-mm), **as directed**, nominal-thickness steel sheet.
5. Perforated Sides: Fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet with manufacturer's standard diamond perforations.
6. Expanded-Metal Sides: Fabricated from 0.090-inch (2.28-mm) nominal-thickness expanded metal; welded to 0.105-inch (2.66-mm) nominal-thickness steel angles or 0.060-inch (1.52-mm) nominal-thickness steel channel frames.
7. Frames: Channel formed; fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet or 0.097-inch (2.45-mm) nominal-thickness steel angles; lapped and factory welded at corners; with top and bottom main frames factory welded into vertical main frames. Form continuous, integral door strike full height on vertical main frames.
   a. Cross Frames for Double-Tier **OR** Triple-Tier, **as directed**, Lockers: Channel formed and fabricated from same material as main frames; welded to vertical main frames.
8. Reinforced Bottoms: Structural channels, formed from 0.060-inch (1.52-mm) **OR** 0.075-inch (1.90-mm), **as directed**, nominal-thickness steel sheet; welded to front and rear of side-panel frames.
9. Perforated Doors: One piece; fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet with manufacturer's standard diamond perforations; formed into channel shape with double bend at vertical edges and with right-angle single bend at horizontal edges and latch point (bottom) and right-angle single bend at remaining edges for box lockers.
   a. Reinforcement: Manufacturer's standard reinforcing angles, channels, or stiffeners for doors more than 15 inches (381 mm) wide; welded to inner face of doors.
10. Expanded-Metal Doors: Fabricated from 0.090-inch (2.28-mm) nominal-thickness expanded metal; welded to 0.105-inch (2.66-mm) nominal-thickness steel angle frame; with 0.090-inch (2.28-mm) nominal-thickness, steel sheet lock panel backed by 0.060-inch (1.52-mm) nominal-thickness steel sheet retainer welded to door frame.
11. Hinges: Welded to door and attached to door frame with no fewer than two factory-installed rivets per hinge that are completely concealed and tamper resistant when door is closed; fabricated to swing 180 degrees; self-closing, **as directed**.
   a. Knuckle Hinges: Steel, full loop, five or seven knuckles, tight pin; minimum 2 inches (51 mm) high. Provide no fewer than three hinges for each door more than 42 inches (1067 mm) high.
   b. Continuous Hinges: Manufacturer's standard, steel; side or top mounted as required by locker configuration.

c. Hinges: Manufacturer's standard, steel continuous or knuckle type.

12. Recessed Door Handle and Latch: Stainless-steel cup with integral door pull, recessed so locking device does not protrude beyond face of door; pry and vandal resistant.
    a. Multipoint Latching: Finger-lift latch control designed for use with built-in combination locks, built-in cylinder locks, or padlocks; positive automatic latching and prelocking.
        1) Latch Hooks: Equip doors 48 inches (1219 mm) and higher with three latch hooks and doors less than 48 inches (1219 mm) high with two latch hooks; fabricated from 0.120-inch (3.04-mm) nominal-thickness steel sheet; welded to full-height door strikes; with resilient silencer on each latch hook.
        2) Latching Mechanism: Manufacturer's standard, rattle-free latching mechanism and moving components isolated to prevent metal-to-metal contact, and incorporating a prelocking device that allows locker door to be locked while door is open and then closed without unlocking or damaging lock or latching mechanism.
    b. Single-Point Latching: Nonmoving latch hook designed to engage bolt of built-in combination or cylinder lock **OR** with steel padlock loop that projects through recessed cup and is finished to match metal locker body, **as directed**.
        1) Latch Hook: Equip each door with one latch hook, fabricated from 0.120-inch (3.04-mm) nominal-thickness steel sheet; welded midway up full-height door strike; with resilient silencer.
13. Projecting Turn-Handle and Latch: Steel handle welded to manufacturer's standard, three-point, cremone-type latching mechanism consisting of steel rods or bars that engage main locker frame at top and bottom of door, and center latch that engages strike jamb; with steel padlock loop.
14. Door Handle and Latch for Box Lockers: Stainless-steel strike plate with integral pull; with steel padlock loop that projects through metal locker door.
15. Combination Padlocks: Key-controlled, three-number dialing combination locks; capable of five combination changes **OR** Provided by Owner, **as directed**.
16. Built-in Combination Locks: Key-controlled, three-number dialing combination locks; capable of at least five combination changes made automatically with a control key.
    a. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.
17. Cylinder Locks: Built-in, flush, cam locks with five-pin tumbler keyway, keyed separately and master keyed. Furnish two change keys for each lock and two, **as directed**, master keys.
    a. Key Type: Flat **OR** Grooved, **as directed**, with minimum 2- by 2.68-inch (51- by 68.3-mm) key head for accessible lockers, **as directed**.
    b. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.
18. Equipment: Equip each metal locker with identification plate and the following unless otherwise indicated:
    a. Single-Tier Units: Shelf, one double-prong ceiling hook, and two single-prong wall hooks.
    b. Double-Tier Units: One double-prong ceiling hook and two single-prong wall hooks.
    c. Triple-Tier Units: One double-prong ceiling hook.
    d. Coat Rods: As indicated on Drawings **OR** For each compartment of single-tier, double-tier and triple-tier metal lockers **OR** In lieu of ceiling hook for metal lockers 24 inches (610 mm) high or more **OR** In lieu of ceiling hook for metal lockers 18 inches (457 mm) deep or more, **as directed**.
19. Accessories:
    a. Legs: 6 inches (152 mm) high; formed by extending vertical frame members, or fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; welded to bottom of locker.
        1) Closed Front and End Bases: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
    b. Continuous Zee Base: 4 inches (102 mm) high; fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet.
    c. Continuous Sloping Tops: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet, with a pitch of approximately 20 degrees.
        1) Closures: Vertical-end **OR** Hipped-end, **as directed**, type.
    d. Recess Trim: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.

e. Filler Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
f. Boxed End Panels: Fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet.

20. Finish: Baked enamel **OR** Powder coat, **as directed**.
    a. Color(s): As selected from manufacturer's full range **OR** Two colors, with door one color and frame and body another color; as selected from manufacturer's full range, **as directed**.

E. Open-Front Athletic Metal Lockers

1. Locker Arrangement: Open front, with seat/shelf **OR** seat/footlocker, upper shelf **OR** upper shelf with security box **OR** full-width security compartment **OR** configuration as indicated on Drawings, **as directed**.
2. Material: Cold-rolled **OR** Metallic-coated, **as directed**, steel sheet.
3. Body: Assembled by welding **OR** riveting or bolting, **as directed**, body components together. Fabricate from unperforated steel sheet with thicknesses as follows:
    a. Tops and Bottoms: 0.060-inch (1.52-mm) nominal thickness, with single bend at edges.
    b. Backs: 0.048-inch (1.21-mm) nominal thickness.
    c. Shelves: 0.060-inch (1.52-mm) nominal thickness, with double bend at front and single bend at sides and back.
4. Unperforated Sides: Fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet.
5. Perforated Sides: Fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet with manufacturer's standard diamond perforations. Perforations shall not occur above upper shelf **OR** at security compartment **OR** at seat/footlocker, **as directed**.
6. Expanded-Metal Sides: Fabricated from 0.090-inch (2.28-mm) nominal-thickness expanded metal; welded to 0.105-inch (2.66-mm) nominal-thickness steel angles or 0.060-inch (1.52-mm) nominal-thickness steel channel frames.
7. Frames: Channel formed; fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet or 0.105-inch (2.66-mm) nominal-thickness steel angles; lapped and factory welded at corners; with top and bottom main frames factory welded into vertical main frames.
8. Reinforced Bottoms: Structural channels, formed from 0.075-inch (1.90-mm) nominal-thickness steel sheet; welded to front and rear of side-panel frames.
9. Seats/Shelves: Full width of metal locker; channel formed; fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet; with stiffeners for reinforcement.
10. Seats/Footlockers: Enclosure full width of bottom of metal locker; fabricated from cold-rolled steel sheet.
    a. Seat/Lid: 0.075-inch (1.90-mm) nominal-thickness steel sheet; channel formed and reinforced with stiffeners; with manufacturer's standard, steel continuous hinge that is completely concealed and tamper resistant when seat/lid is closed; with padlock hasp.
    b. Front Panel: 0.075-inch (1.90-mm) nominal-thickness steel sheet; channel formed at top edge; with minilouvers for ventilation; recessed for padlock loop.
    c. Sides: Integral part of unperforated **OR** Unperforated bottom portions of perforated **OR** 0.060-inch (1.52-mm) nominal-thickness steel sheet inside expanded-metal, **as directed**, sides.
11. Security Boxes: Consisting of partition extending from upper shelf to top of metal locker, fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet; with channel-formed, 0.060-inch (1.52-mm) nominal-thickness, steel sheet door frame, and door fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet with right-angle single bend at edges; with manufacturer's standard, steel continuous hinge that is completely concealed and tamper resistant when door is closed; fabricated to swing 180 degrees.
    a. Single-Point Latching: Stainless-steel strike plate with integral pull; with steel, nonmoving latch hook designed to engage bolt of built-in combination or cylinder lock **OR** with steel padlock loop that projects through door and is finished to match metal locker body, **as directed**.
12. Security Compartments: Full width of metal locker, with door fabricated from 0.075-inch (1.90-mm) nominal-thickness steel sheet.
13. Combination Padlocks: Key-controlled, three-number dialing combination locks; capable of five combination changes **OR** Provided by Owner, **as directed**.

14. Built-in Combination Locks: Key-controlled, three-number dialing combination locks; capable of at least five combination changes made automatically with a control key.
    a. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.
15. Cylinder Locks: Built-in, flush, cam locks with five-pin tumbler keyway, keyed separately and master keyed. Furnish two change keys for each lock and two, **as directed**, master keys.
    a. Key Type: Flat **OR** Grooved, **as directed**, with minimum 2- by 2.68-inch (51- by 68.3-mm) key head for accessible lockers, **as directed**.
    b. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.
16. Equipment: Equip each metal locker with identification plate and the following unless otherwise indicated:
    a. Two single-prong wall hooks bolted to locker back.
    b. Coat rod and two rod holders.
17. Accessories:
    a. Continuous Sloping Tops: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet, with a pitch of approximately 20 degrees.
        1) Closures: Vertical-end **OR** Hipped-end, **as directed**, type.
    b. Recess Trim: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
    c. Filler Panels: Fabricated from 0.048-inch (1.21-mm) nominal-thickness steel sheet.
    d. Boxed End Panels: Fabricated from 0.060-inch (1.52-mm) nominal-thickness steel sheet.
18. Finish: Baked enamel **OR** Powder coat, **as directed**.
    a. Color(s): As selected from manufacturer's full range **OR** Two colors; as selected from manufacturer's full range, **as directed**.

F. Coin-Operated Metal Lockers
1. Steel Lockers: Fabricated from cold-rolled steel sheet with thicknesses as follows:
    a. Tops, Bottoms, Sides, and Shelves: 0.024-inch (0.61-mm) nominal thickness.
    b. Backs: 0.036-inch (0.91-mm) nominal thickness.
    c. Frames: 0.060-inch (1.52-mm) nominal thickness.
    d. Doors: 0.060-inch (1.52-mm) nominal thickness.
    e. Exposed Ends of Nonrecessed Lockers: 0.060-inch (1.52-mm) nominal thickness.
2. Stainless-Steel Lockers: Fabricated from stainless-steel sheet with thicknesses and finishes as follows:
    a. Tops, Bottoms, Sides, Backs, and Shelves: 0.025 inch (0.64 mm) thick, with No. 2B finish.
    b. Frames: 0.062 inch (1.59 mm) thick, with No. 3 or No. 4 finish.
    c. Doors: 0.062 inch (1.59 mm) thick, with manufacturer's standard patterned finish.
    d. Exposed Ends of Nonrecessed Lockers: 0.062 inch (1.59 mm) thick, with No. 3 or No. 4 finish.
3. Body: Assembled by welding or riveting body components to frames using manufacturer's standard aluminum or stainless-steel rivets; flanged for double thickness at back vertical corners; back ventilated.
4. Frames: Channel formed; lapped and welded at corners; with top, bottom, and cross frames welded into vertical main frames. Form continuous, integral door strike full height on vertical main frames, and equip frames with resilient bumpers to cushion door closing.
    a. Cross Frames between Tiers: Channel formed and fabricated from same material as main frames; welded to vertical main frame.
5. Doors: One piece; formed into channel shape at vertical edges and flanged at right angles at horizontal edges; fabricated to swing 180 degrees. Brace or reinforce inner face of doors with manufacturer's standard reinforcing angles, channels, or stiffener panels.
6. Hinges: Manufacturer's standard, full-loop, five- or seven-knuckle type; tight pin; minimum 2-1/2 inches (64 mm) high or continuous type, of same material as door; self-closing, **as directed**. Weld hinge to inside of door frame and attach hinge to door with factory-installed fasteners that are completely concealed and tamper resistant when door is closed.
    a. Provide at least three hinges for each door more than 42 inches (1067 mm) high.
7. Projecting Door Handle: Manufacturer's standard; stainless steel; pry and vandal resistant.

8. Built-in, Coin-Operated Locks: Self-contained units mounted on interior of door with replaceable lock cylinders keyed separately and master keyed. Mount instruction decals on both faces of door. Furnish one change key for each lock and one master key.
   a. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.
   b. Lock Type: Fee return/deposit **OR** collect/pay, **as directed**.
   c. Fee Type: Token **OR** Coin, one quarter **OR** Coin, two quarters, **as directed**.
   d. Coin Box: Manufacturer's standard housing or stainless-steel cash box with stainless-steel flanged cover set into base of lock channel frame. Furnish with removable cylinder and key, and master code changer key.
9. Finish: Baked enamel **OR** Powder coat, **as directed**.
   a. Color(s): As selected from manufacturer's full range **OR** Two colors, with door one color and frame and body another color; as selected from manufacturer's full range, **as directed**.

G. Keyless Locks
1. Built-in, Card-Operated Locks: Self-contained units mounted on interior of door with replaceable lock cylinders keyed separately and master keyed. Mount instruction decals on both faces of door. Furnish one change card key for each lock and one master card key.
   a. Bolt Operation: Manually locking deadbolt **OR** automatically locking spring bolt, **as directed**.
2. Digital Keypad Locks: Battery-powered electronic keypad with reprogrammable manager and owner codes that override access. Three consecutive incorrect code entries shall disable lock for three minutes.
   a. Designed for permanently assigned access via entry of user's four-digit code.
   b. Designed for shared or temporary access by multiple users, with user-defined code to lock and unlock. Provide LED indicator to show when lock is in use.

H. Locker Benches
1. Provide bench units with overall assembly height of 17-1/2 inches (445 mm).
2. Bench Tops: Manufacturer's standard one-piece units, with rounded corners and edges.
   a. Size: Minimum 9-1/2 inches wide by 1-1/4 inches thick (241 mm wide by 32 mm thick) except provide minimum 20-inch- (508-mm-) wide tops where accessible benches are indicated.
   b. Laminated clear hardwood with one coat of clear sealer on all surfaces and one coat of clear lacquer on top and sides.
   c. Plastic laminate over particleboard core, with two steel tubes running full length of top and positioned to receive pedestal fasteners.
      1) Color: As selected from manufacturer's full range.
   d. Extruded aluminum with clear anodic finish.
3. Fixed Pedestals: Manufacturer's standard supports, with predrilled fastener holes for attaching bench top and anchoring to floor, complete with fasteners and anchors, and as follows:
   a. Tubular Steel: 1-1/2-inch- (38-mm-) diameter steel tubing threaded on both ends, with standard pipe flange at top and bell-shaped cast-iron base; with baked-enamel or powder-coat finish; anchored with exposed fasteners.
      1) Color: As selected from manufacturer's full range.
   b. Tubular Steel: 1-1/4-inch- (32-mm-) diameter steel tubing, with 0.1265-inch- (3.2-mm-) thick steel flanges welded at top and base; with baked-enamel **OR** zinc-plated, **as directed**, finish; anchored with exposed fasteners.
      1) Color: As selected from manufacturer's full range.
4. Freestanding Pedestals: Manufacturer's standard supports, with predrilled fastener holes for attaching bench top, complete with fasteners, and as follows:
   a. Aluminum: 1/8-inch-thick by 3-inch-wide (3-mm-thick by 76-mm-wide) channel or 1/4-inch-thick by 3-inch-wide (6-mm-thick by 76-mm-wide) bar stock, shaped into trapezoidal **OR** inverted-T, **as directed**, form; with nonskid pads at bottom.
      1) Finish: Clear **OR** Black **OR** Gold, **as directed**, anodic finish.

b. Stainless Steel: 1/8-inch-thick by 3-inch-wide (3-mm-thick by 76-mm-wide) channel or 1/4-inch-thick by 3-inch-wide (6-mm-thick by 76-mm-wide) bar stock, shaped into trapezoidal form; with nonskid pads at bottom. Add finish.

I. Fabrication

1. Fabricate metal lockers square, rigid, and without warp and with metal faces flat and free of dents or distortion. Make exposed metal edges safe to touch and free of sharp edges and burrs.
   a. Form body panels, doors, shelves, and accessories from one-piece steel sheet unless otherwise indicated.
   b. Provide fasteners, filler plates, supports, clips, and closures as required for complete installation.
2. Fabricate each metal locker with an individual door and frame; individual top, bottom, and back; and common intermediate uprights separating compartments. Factory weld frame members of each metal locker together to form a rigid, one-piece assembly.
3. Knocked-Down Construction: Fabricate metal lockers using nuts, bolts, screws, or rivets for nominal assembly at Project site **OR** preassembly at plant prior to shipping, **as directed**.
4. All-Welded Construction: Factory preassemble metal lockers by welding all joints, seams, and connections; with no bolts, nuts, screws, or rivets used in assembly of main locker groups. Factory weld main locker groups into one-piece structures. Grind exposed welds flush.
5. Accessible Lockers: Fabricate as follows:
   a. Locate bottom shelf no lower than 15 inches (381 mm) above the floor.
   b. Where hooks, coat rods, or additional shelves are provided, locate no higher than 48 inches (1219 mm) above the floor.
6. Hooks: Manufacturer's standard ball-pointed type, aluminum or steel; zinc plated.
7. Coat Rods: Fabricated from 1-inch- (25-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, diameter steel, chrome finished **OR** nickel plated, **as directed**.
8. Identification Plates: Manufacturer's standard, etched, embossed, or stamped aluminum **OR** plastic, **as directed**, plates, with numbers and letters at least 3/8 inch (9 mm) high.
9. Continuous Base: Formed into channel or zee profile for stiffness, and fabricated in lengths as long as practical to enclose base and base ends of metal lockers; finished to match lockers.
10. Continuous Sloping Tops: Fabricated in lengths as long as practical, without visible fasteners at splice locations; finished to match lockers.
    a. Sloping-top corner fillers, mitered.
11. Individual Sloping Tops: Fabricated in width to fit one locker frame in lieu of flat locker tops; with integral back; finished to match lockers. Provide wedge-shaped divider panels between lockers.
12. Recess Trim: Fabricated with minimum 2-1/2-inch (64-mm) face width and in lengths as long as practical; finished to match lockers.
13. Filler Panels: Fabricated in an unequal leg angle shape; finished to match lockers. Provide slip-joint filler angle formed to receive filler panel.
14. Boxed End Panels: Fabricated with 1-inch- (25-mm-) wide edge dimension, and designed for concealing fasteners and holes at exposed ends of nonrecessed metal lockers; finished to match lockers.
    a. Provide one-piece panels for double-row (back-to-back) locker ends.
15. Finished End Panels: Designed for concealing unused penetrations and fasteners, except for perimeter fasteners, at exposed ends of nonrecessed metal lockers; finished to match lockers.
    a. Provide one-piece panels for double-row (back-to-back) locker ends.
16. Center Dividers: Full-depth, vertical partitions between bottom and shelf; finished to match lockers.

J. Steel Sheet Finishes

1. Factory finish steel surfaces and accessories except stainless-steel and chrome-plated surfaces.
2. Baked-Enamel Finish: Immediately after cleaning, pretreating, and phosphatizing, apply manufacturer's standard thermosetting baked-enamel finish. Comply with paint manufacturer's written instructions for application, baking, and minimum dry film thickness.

3. Powder-Coat Finish: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard, baked-polymer, thermosetting powder finish. Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

K. Stainless-Steel Finishes
1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
   a. Run grain of directional finishes with long dimension of each piece.
   b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

A. Installation
1. General: Install level, plumb, and true; shim as required, using concealed shims.
   a. Anchor locker runs at ends and at intervals recommended by manufacturer, but not more than 36 inches (910 mm) o.c. Using concealed fasteners, install anchors through backup reinforcing plates, channels, or blocking as required to prevent metal distortion.
   b. Anchor single rows of metal lockers to walls near top and bottom of lockers **OR** of lockers and to floor, **as directed**.
   c. Anchor back-to-back metal lockers to floor.
2. Knocked-Down Metal Lockers: Assemble with standard fasteners, with no exposed fasteners on door faces or face frames.
3. All-Welded Metal Lockers: Connect groups together with standard fasteners, with no exposed fasteners on face frames.
4. Equipment and Accessories: Fit exposed connections of trim, fillers, and closures accurately together to form tight, hairline joints, with concealed fasteners and splice plates.
   a. Attach hooks with at least two fasteners.
   b. Attach door locks on doors using security-type fasteners.
   c. Identification Plates: Identify metal lockers with identification indicated on Drawings.
      1) Attach plates to each locker door, near top, centered, with at least two aluminum rivets.
      2) Attach plates to upper shelf of each open-front metal locker, centered, with a least two aluminum rivets.
   d. Attach recess trim to recessed metal lockers with concealed clips.
   e. Attach filler panels with concealed fasteners. Locate filler panels where indicated on Drawings.
   f. Attach sloping-top units to metal lockers, with closures at exposed ends.
   g. Attach boxed end panels with concealed fasteners to conceal exposed ends of nonrecessed metal lockers.
   h. Attach finished end panels with fasteners only at perimeter to conceal exposed ends of nonrecessed metal lockers.
5. Fixed Locker Benches: Provide no fewer than two pedestals for each bench, uniformly spaced not more than 72 inches (1830 mm) apart. Securely fasten tops of pedestals to undersides of bench tops, and anchor bases to floor.
6. Freestanding Locker Benches: Place benches in locations indicated on Drawings.

B. Adjusting, Cleaning, And Protection
1. Clean, lubricate, and adjust hardware. Adjust doors and latches to operate easily without binding. Verify that integral locking devices operate properly.
2. Protect metal lockers from damage, abuse, dust, dirt, stain, or paint. Do not permit use during construction.

3. Touch up marred finishes, or replace metal lockers that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by locker manufacturer.

END OF SECTION 10503

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Task	Specification	Specification Description
10503	01352	No Specification Required
10504	10503	Metal Lockers

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SECTION 10505 - SOLID PLASTIC LOCKERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for solid plastic lockers. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Shop Drawings: Submitted shop drawings showing individual locker construction and overall dimensions, including complete installation instructions.

C. Product Handling
1. Store locker components flat until assembly. Protect all finishes from soiling and damage during handling.

D. Warranty
1. Manufacturer shall warranty lockers for a period of 10 years against rust and other types of corrosion, delamination, or breakage of any of the plastic panels, doors, and shelves under normal use.

1.2 PRODUCTS

A. Materials: Sides, tips, bottoms, rears, doors, and shelves shall be made from high impact, high density polyethylene (HDPE) formed under high pressure into solid plastic components 3/8" thick with homogeneous color throughout. All panels, doors, and shelves will match in color.
1. Material testing: All solid plastic components shall resist deterioration and discoloration when subjected to any of the following:
Acetic Acid 80%
Acetone
Ammonia Liquid
Ammonium Phosphate
Bleach 12%
Borax
Brine
Caustic Soda
Chlorine Water
Citric Acid
Copper Chloride
Core Oils
Hydrochloric Acid 40%
Hydrogen Peroxide 30%
Isopropyl Alcohol
Lactic Acid 25%
Lime Sulfur
Nicotine
Potassium Bromide
Soaps
Sodium Bicarbonate
Trisodium Phosphate
Urea and Urine

Vinegar
(Testing in accordance with corrosion testing procedure established by the United States Plastic Corporation)

2. Continuous latch, capable of accepting various locking mechanisms, shall be securely fastened to the entire length of the door, providing a continuous security latch.
3. Door hinge shall be made from plastic with no steel or metal parts. Door hinge shall be continuous and integrated into the full length of the door and main locker body.
4. Coat hooks shall be made from chrome plated steel and attached with tempered screws.
5. All components shall have a smooth "orange peel" finish. All components shall be of the same color and selected from the manufacturer's full color line.

B. Fabrication
1. Locker components shall be fabricated square and rigid with a finish free of scratches and chips. All sides, tops, bottoms, backs, doors, and shelves shall be coated on both sides with a protective masking.
2. Solid plastic locker components shall snap together for easy assembly and shall provide a solid and secure construction. Adjacent lockers shall share a common side panel. Locker units shall be manufactured for assembly in a group of no more than five adjacent lockers.

1.3 EXECUTION

A. Installation
1. Install lockers at the location shown in accordance with the manufacturer's instructions for plumb, level, rigid, and flush installations.
2. Anchor the units to wall studs through the locker back and to the floor using #8 pan head wood screws. Furring must be installed between lockers and wall of installations.
3. Lockers can be either floor-mounted or installed on a 4" high base. Hardware and instructions for either method shall be provided by the manufacturer.
4. Number plates shall be available for field or factory mounting.

END OF SECTION 10505

Task	Specification	Specification Description
10507	01352	No Specification Required

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SECTION 10521 - FIRE EXTINGUISHER CABINETS

1.1 GENERAL

A. Description Of Work:
1. This specification covers the furnishing and installation of materials for fire extinguisher cabinets. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fire protection cabinets for the following:
1) Portable fire extinguishers.
2) Fire hose valves.
3) Fire hoses and racks.

C. Submittals
1. Product Data: For each type of product indicated.
2. Show location of knockouts for hose valves.
3. Shop Drawings: For fire protection cabinets. Include plans, elevations, sections, details, and attachments to other work.
4. Samples: For each type of fire protection cabinet indicated.
5. Maintenance Data.

D. Quality Assurance
1. Fire-Rated, Fire Protection Cabinets: Listed and labeled to comply with requirements in ASTM E 814 for fire-resistance rating of walls where they are installed.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Coordination
1. Coordinate size of fire protection cabinets to ensure that type and capacity of fire extinguishers indicated are accommodated.
2. Coordinate size of fire protection cabinets to ensure that type and capacity of fire hoses, hose valves, and hose racks indicated are accommodated.
3. Coordinate sizes and locations of fire protection cabinets with wall depths.

F. Sequencing
1. Apply decals **OR** vinyl lettering, **as directed**, on field-painted, fire protection cabinets after painting is complete.

1.2 PRODUCTS

A. Materials
1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
2. Aluminum: Alloy and temper recommended by aluminum producer and manufacturer for type of use and finish indicated, and as follows:
a. Sheet: ASTM B 209 (ASTM B 209M).
b. Extruded Shapes: ASTM B 221 (ASTM B 221M).
3. Stainless-Steel Sheet: ASTM A 666, Type 304.
4. Copper-Alloy Brass Sheet: ASTM B 36/B 36M, alloy UNS No. C26000 (cartridge brass, 70 percent copper).

5. Copper-Alloy Bronze Sheet: ASTM B 36/B 36M, alloy UNS No. C28000 (muntz metal, 60 percent copper).
6. Clear Float Glass: ASTM C 1036, Type I, Class 1, Quality q3, 3 **OR** 6, **as directed**, mm thick.
7. Tempered Float Glass: ASTM C 1048, Kind FT, Condition A, Type I, Quality q3, 3 mm thick, Class 1 (clear) **OR** Class 2 (tinted, heat absorbing, and light reducing), bronze tint, **as directed**.
8. Break Glass: Clear annealed float glass, ASTM C 1036, Type I, Class 1, Quality q3, 1.5 mm thick, single strength.
9. Tempered Break Glass: ASTM C 1048, Kind FT, Condition A, Type I, Quality q3, 1.5 mm thick.
10. Wire Glass: ASTM C 1036, Type II, Class 1, Form 1, Quality q8, Mesh m1 (diamond), 6 mm thick.
11. Transparent Acrylic Sheet: ASTM D 4802, Category A-1 (cell-cast sheet), 1.5 **OR** 3 **OR** 6, **as directed**, mm thick, with Finish 1 (smooth or polished) **OR** Finish 2 (patterned, textured), **as directed**.
12. Acrylic Bubble: One piece.

B. Fire Protection Cabinet
1. Cabinet Type: Suitable for fire extinguisher **OR** extinguisher and hose valve **OR** hose, rack, valve, and extinguisher **OR** hose, rack, and valve **OR** hose valve, **as directed**.
2. Cabinet Construction: Nonrated **OR** 1-hour fire rated **OR** 2-hour fire rated, **as directed**.
   a. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls fabricated from 0.0428-inch- (1.1-mm-) thick, cold-rolled steel sheet lined with minimum 5/8-inch- (16-mm-) thick, fire-barrier material. Provide factory-drilled mounting holes.
3. Cabinet Material: Steel **OR** Aluminum **OR** Stainless-steel, **as directed**, sheet.
   a. Shelf: Same metal and finish as cabinet.
4. Recessed Cabinet: Cabinet box recessed in walls of sufficient depth to suit style of trim indicated.
   a. Trimless with Concealed Flange: Surface of surrounding wall finishes flush with exterior finished surface of cabinet frame and door, without overlapping trim attached to cabinet. Provide recessed flange, of same material as box, attached to box to act as plaster stop **OR** drywall bead, **as directed**.
   b. Trimless with Hidden Flange: Flange of same metal and finish as box overlaps surrounding wall finish and is concealed from view by an overlapping door.
   c. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).
5. Semirecessed Cabinet: Cabinet box partially recessed in walls of sufficient depth to suit style of trim indicated; with one-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend). Provide where walls are of insufficient depth for recessed cabinets but are of sufficient depth to accommodate semirecessed cabinet installation.
   a. Square-Edge Trim: 1-1/4- to 1-1/2-inch (32- to 38-mm) backbend depth.
   b. Rolled-Edge Trim: 2-1/2-inch (64-mm) **OR** 4-inch (102-mm) **OR** 4-1/2-inch (114-mm), **as directed**, backbend depth.
6. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall with no trim. Provide where walls are of insufficient depth for semirecessed cabinet installation.
7. Cabinet Trim Material: Steel sheet **OR** Aluminum sheet **OR** Extruded-aluminum shapes **OR** Stainless-steel sheet **OR** Copper-alloy brass sheet **OR** Copper-alloy bronze sheet **OR** Same material and finish as door, **as directed**.
8. Door Material: Steel sheet **OR** Aluminum sheet **OR** Extruded-aluminum shapes **OR** Stainless-steel sheet **OR** Copper-alloy brass sheet **OR** Copper-alloy bronze sheet, **as directed**.
9. Door Style: Fully glazed, frameless, backless, acrylic panel **OR** Fully glazed panel with frame **OR** Full bubble, frameless **OR** Full bubble with frame **OR** Full bubble with frameless, rotating turntable **OR** Horizontal duo panel with frame **OR** Vertical duo panel with frame **OR** Center glass panel with frame **OR** Solid opaque panel with frame **OR** Flush opaque panel, frameless, with no exposed hinges, **as directed**.

10. Door Glazing: Clear float glass **OR** Tempered float glass (clear) **OR** Tempered float glass (bronze tint) **OR** Break glass **OR** Tempered break glass **OR** Wire glass **OR** Mirror glass **OR** Acrylic sheet **OR** Break acrylic bubble **OR** Molded acrylic bubble, **as directed**.
    a. Acrylic Sheet Color: Clear **OR** Bronze, **as directed**, transparent acrylic sheet.
    b. Acrylic Sheet Color: Clear transparent acrylic sheet painted white **OR** red **OR** black, **as directed**, on unexposed side.
    c. Acrylic Bubble Color: Clear **OR** Bronze **OR** Red, **as directed**, transparent.
11. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated.
    a. Provide projecting lever handle with cam-action latch **OR** projecting door pull and friction latch **OR** recessed door pull and friction latch **OR** manufacturer's standard, **as directed**.
    b. Provide continuous hinge, of same material and finish as trim, **OR** concealed hinge **OR** pivot hinge **OR** manufacturer's standard hinge, **as directed,** permitting door to open 180 degrees.
12. Accessories:
    a. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to fire protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
    b. Break-Glass Strike: Manufacturer's standard metal strike, complete with chain and mounting clip, secured to cabinet.
    c. Lettered Door Handle: One-piece, cast-iron door handle with the word "FIRE" embossed into face.
    d. Door Lock: Cam lock that allows door to be opened during emergency by pulling sharply on door handle **OR** Cylinder lock, keyed alike to other cabinets, **as directed**.
    e. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as directed.
        1) Identify fire extinguisher in fire protection cabinet with the words "FIRE EXTINGUISHER."
            a) Location: Applied to cabinet door **OR** cabinet glazing **OR** location indicated on Drawings, **as directed**.
            b) Application Process: Silk-screened **OR** Engraved **OR** Etched **OR** Decals **OR** Pressure-sensitive vinyl letters, **as directed**.
            c) Lettering Color: Red **OR** Black **OR** White, **as directed**.
            d) Orientation: Vertical **OR** Horizontal **OR** As indicated on Drawings, **as directed**.
    f. Alarm: Manufacturer's standard alarm that actuates when fire protection cabinet door is opened and that is powered by batteries **OR** low voltage, complete with transformer, **as directed**.
13. Finishes:
    a. Manufacturer's standard baked-enamel paint for the following:
        1) Exterior of cabinet door **OR** trim, **OR** door, and trim, **as directed,** except for those surfaces indicated to receive another finish.
        2) Interior of cabinet and door, **as directed**.
    b. Aluminum: Clear anodic **OR** Color anodic **OR** Baked enamel or powder coat, **as directed**.
    c. Steel: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
    d. Stainless Steel: No. 2B **OR** No. 4 **OR** No. 6 **OR** No. 7 **OR** No. 8, **as directed**.
    e. Copper Alloy, Brass: Buffed **OR** Hand rubbed **OR** Hand rubbed, lacquered **OR** Medium satin **OR** Fine matte **OR** Statuary conversion **OR** Patina conversion, **as directed**.
    f. Copper Alloy, Bronze: Buffed **OR** Hand rubbed **OR** Hand rubbed, lacquered **OR** Medium satin **OR** Fine matte **OR** Statuary conversion **OR** Patina conversion, **as directed**.

C. Security Fire Protection Cabinet
1. Cabinet Type: Suitable for fire extinguisher **OR** extinguisher and hose valve **OR** hose, rack, valve, and extinguisher **OR** hose, rack, and valve **OR** hose valve, **as directed**.
2. Cabinet Construction: Nonrated **OR** 1-hour fire rated **OR** 2-hour fire rated, **as directed**.

a. Fire-Rated Cabinets: Construct fire-rated cabinets with double walls lined with minimum 5/8-inch- (16-mm-) thick, fire-barrier material.

3. Cabinet Material: 0.0677-inch- (1.7-mm-) thick steel **OR** 0.0966-inch- (2.5-mm-) thick steel **OR** 0.0781-inch- (2.0-mm-) thick, stainless-steel, **as directed,** sheet.
   a. Shelf: Same metal and finish as cabinet.
4. Recessed Cabinet: Cabinet box recessed in walls of sufficient depth to suit style of trim indicated.
   a. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).
5. Semirecessed Cabinet: Cabinet box partially recessed in walls of sufficient depth to suit style of trim indicated; with one-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend). Provide where walls are of insufficient depth for recessed cabinets but are of sufficient depth to accommodate semirecessed cabinet installation.
   a. Square-Edge Trim: 1-1/4- to 1-1/2-inch (32- to 38-mm) backbend depth.
   b. Rolled-Edge Trim: 2-1/2-inch (64-mm) backbend depth.
6. Surface-Mounted Cabinet: Cabinet box fully exposed and mounted directly on wall; with no trim. Provide where walls are of insufficient depth for semirecessed cabinet installation.
7. Cabinet Trim Material: Steel sheet **OR** Stainless-steel sheet **OR** Same material and finish as door, **as directed**.
8. Door Material: 0.0966-inch- (2.5-mm-) thick steel **OR** 0.0781-inch- (2.0-mm-) thick, stainless-steel **OR** 0.1094-inch- (2.8-mm-) thick, stainless-steel, **as directed,** sheet.
9. Door Style: Solid opaque panel with frame.
10. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material and style indicated, and as follows:
    a. Recessed door pull.
    b. Continuous Hinge: Same material and finish as trim, permitting door to open 180 degrees.
    c. Mechanical Deadlock: Lockbolt retracted and extended by five-tumbler paracentric **OR** mogul, **as directed,** cylinder; keyed one side.
       1) Lockbolt: 1-1/2 inches high by 3/4 inch (38 mm high by 19 mm) thick; 5/8-inch (16-mm) throw.
    d. Mechanical Deadlock: As specified in Division 08 Section "Detention Door Hardware".
    e. Mechanical Snaplatch: Automatic snaplatch when closed; latchbolt retracted by five-tumbler paracentric **OR** mogul, **as directed,** cylinder; keyed one side.
       1) Lockbolt: 1 inch high by 7/16 inch (25 mm high by 11 mm) thick; 5/16-inch (8-mm) throw.
    f. Mechanical Snaplatch: As specified in Division 08 Section "Detention Door Hardware".
11. Accessories:
    a. Mounting Bracket: Manufacturer's standard steel, designed to secure fire extinguisher to security fire protection cabinet, of sizes required for types and capacities of fire extinguishers indicated, with plated or baked-enamel finish.
    b. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as directed.
       1) Identify fire extinguisher in security fire protection cabinet with the words "FIRE EXTINGUISHER."
          a) Location: Applied to cabinet door **OR** location indicated on Drawings, **as directed**.
          b) Application Process: Silk-screened **OR** Engraved **OR** Etched **OR** Decals **OR** Pressure-sensitive vinyl letters, **as directed**.
          c) Lettering Color: Red **OR** Black **OR** White, **as directed**.
          d) Orientation: Vertical **OR** Horizontal **OR** As indicated on Drawings, **as directed**.
    c. Keys to Door Locks: Three per lock.
12. Finishes:
    a. Manufacturer's standard baked-enamel paint for the following:

1) Exterior of cabinet door **OR** trim, **OR** door, and trim, **as directed,** except for those surfaces indicated to receive another finish.
2) Interior of cabinet and door, **as directed**.

b. Steel: Factory primed for field painting **OR** Baked enamel or powder coat, **as directed**.
c. Stainless Steel: No. 4 finish.

D. Fabrication
1. Fire Protection Cabinets: Provide manufacturer's standard box (tub) with trim, frame, door, and hardware to suit cabinet type, trim style, and door style indicated.
   a. Weld joints and grind smooth.
   b. Provide factory-drilled mounting holes.
   c. Prepare doors and frames to receive locks.
   d. Install door locks at factory.
2. Cabinet Doors: Fabricate doors according to manufacturer's standards, from materials indicated and coordinated with cabinet types and trim styles selected.
   a. Fabricate door frames with tubular stiles and rails and hollow-metal design, minimum 1/2 inch (13 mm) thick.
   b. Fabricate door frames of one-piece construction with edges flanged.
   c. Miter and weld perimeter door frames.
3. Cabinet Trim: Fabricate cabinet trim in one piece with corners mitered, welded, and ground smooth.

E. General Finish Requirements
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces of fire protection cabinets from damage by applying a strippable, temporary protective covering before shipping.
3. Finish fire protection cabinets after assembly.
4. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

F. Aluminum Finishes
1. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed,** or thicker.
2. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed,** or thicker.
   a. Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black, **as directed**.
   b. Color: As selected from full range of industry colors and color densities, **as directed**.
3. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
   a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

G. Steel Finishes
1. Surface Preparation: Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning" **OR** SSPC-SP 8, "Pickling", **as directed**. After cleaning, apply a conversion coating suited to the organic coating to be applied over it, **as directed**.
2. Factory Prime Finish: Apply manufacturer's standard, fast-curing, lead- and chromate-free, universal primer immediately after surface preparation and pretreatment.
3. Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).

a. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

H. Stainless-Steel Finishes
1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
   a. Run grain of directional finishes with long dimension of each piece.
   b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
   c. Directional Satin Finish: No. 4.
   d. Dull Satin Finish: No. 6.
   e. Reflective, Directional Polish: No. 7.
   f. Mirrorlike Reflective, Nondirectional Polish: No. 8.
3. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

I. Copper-Alloy Finishes
1. Buffed Finish, Lacquered: M21-O6x (Mechanical Finish: buffed, smooth specular; Coating: clear organic, air drying, as specified below).
   a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in 2 coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
2. Hand-Rubbed Finish, Lacquered: M31-M34-O6x (Mechanical Finish: directionally textured, fine satin; Mechanical Finish: directionally textured, hand rubbed; Coating: clear organic, air drying, as specified below).
   a. Clear, Organic Coating: Lacquer specified for copper alloys, applied by air spray in 2 coats per manufacturer's written instructions, with interim drying, to a total thickness of 1 mil (0.025 mm).
3. Statuary Conversion Coating over Satin Finish: M31-C55 (Mechanical Finish: directionally textured, fine satin; Chemical Finish: conversion coating, sulfide).
   a. Color: Match sample.
4. Patina Conversion Coating: CDA-M36-C12-C52 (Mechanical Finish: directionally textured, uniform; Chemical Finish: nonetched cleaned, degreased; Chemical Finish: conversion coating, ammonium sulfate).
   a. Color: Match sample.

1.3 EXECUTION

A. Preparation
1. Prepare recesses for recessed and semirecessed fire protection cabinets as required by type and size of cabinet and trim style.

B. Installation
1. General: Install fire protection cabinets in locations and at mounting heights indicated or, if not indicated, at heights indicated below: or, if not indicated, at heights acceptable to authorities having jurisdiction.
   a. Fire Protection Cabinets: 54 inches (1372 mm) above finished floor to top of cabinet.
2. Fire Protection Cabinets: Fasten cabinets to structure, square and plumb.
   a. Unless otherwise indicated, provide recessed fire protection cabinets. If wall thickness is not adequate for recessed cabinets, provide semirecessed fire protection cabinets.
   b. Provide inside latch and lock for break-glass panels.
   c. Fasten mounting brackets to inside surface of fire protection cabinets, square and plumb.
   d. Fire-Rated, Hose and Valve **OR** Hose-Valve, **as directed**, Cabinets:
      1) Install cabinet with not more than 1/16-inch (1.6-mm) tolerance between pipe OD and knockout OD. Center pipe within knockout.

2) Seal through penetrations with firestopping sealant as specified in Division 07 Section "Through-penetration Firestop Systems".

3. Identification: Apply decals **OR** vinyl lettering, **as directed**, at locations indicated.

C. Adjusting And Cleaning

1. Remove temporary protective coverings and strippable films, if any, as fire protection cabinets are installed unless otherwise indicated in manufacturer's written installation instructions.
2. Adjust fire protection cabinet doors to operate easily without binding. Verify that integral locking devices operate properly.
3. On completion of fire protection cabinet installation, clean interior and exterior surfaces as recommended by manufacturer.
4. Touch up marred finishes, or replace fire protection cabinets that cannot be restored to factory-finished appearance. Use only materials and procedures recommended or furnished by fire protection cabinet and mounting bracket manufacturers.
5. Replace fire protection cabinets that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION 10521

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SECTION 10522 - FIRE EXTINGUISHERS

1.1 GENERAL

A. Description Of Work:
1. This specification covers the furnishing and installation of materials for fire extinguishers. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes portable, hand-carried and wheeled fire extinguishers and mounting brackets for fire extinguishers.
2. Owner-Furnished Material: Hand-carried **OR** Wheeled, **as directed**, fire extinguishers.

C. Submittals
1. Product Data: For each type of product indicated.
2. Operation and maintenance data.
3. Warranty: Sample of special warranty.

D. Quality Assurance
1. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."
2. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.
3. Preinstallation Conference: Conduct conference at Project site.
4. Coordinate type and capacity of fire extinguishers with fire protection cabinets to ensure fit and function.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within six years from date of Substantial Completion.
   a. Failures include, but are not limited to, the following:
      1) Failure of hydrostatic test according to NFPA 10.
      2) Faulty operation of valves or release levers.

1.2 PRODUCTS

A. Portable, Hand-Carried Fire Extinguishers
1. Fire Extinguishers: Type, size, and capacity for each fire protection cabinet **OR** mounting bracket **OR** fire protection cabinet and mounting bracket, **as directed**, indicated.
   a. Valves: Manufacturer's standard **OR** Nickel-plated, polished brass body, **as directed**.
   b. Handles and Levers: Manufacturer's standard **OR** Stainless steel, **as directed**.
   c. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B and bar coding for documenting fire extinguisher location, inspections, maintenance, and recharging.
2. Stored-Pressure Water Type: UL-rated 2-A, 2.5-gal. (9.5-L) nominal capacity, with water in stainless-steel container; with pressure-indicating gage.
3. Stored-Pressure Antifreeze Water Type: UL-rated 2-A, 2.5-gal. (9.5-L) nominal capacity, with water and approved antifreeze solution mixed for temperatures as low as minus 40 deg F (minus 40 deg C) in stainless-steel container; with pressure-indicating gage.

4. Stored-Pressure Water-Mist Type: UL-rated 2-A:C, 2.5-gal. (9.5-L) nominal capacity, with water in enameled-steel container; with pressure-indicating gage.
5. Pressurized, AFFF-Foam Type: UL-rated 2-A:10-B, 1.6-gal. (6-L) **OR** 3-A:20-B, 2.5-gal. (9.5-L), **as directed**, nominal capacity, with AFFF foam in stainless-steel container; with pressure-indicating gage.
6. Pressurized, FFFP-Foam Type: UL-rated 3-A:20-B, 2.5-gal. (9.5-L) nominal capacity, with FFFP foam in stainless-steel container; with pressure-indicating gage.
7. Wet-Chemical Type: UL-rated 2-A:1-B:C:K, 1.6-gal. (6-L) **OR** 2.5-gal. (9.5-L), **as directed**, nominal capacity, with potassium acetate-based **OR** citrate-based **OR** carbonate-based, **as directed**, chemical in stainless-steel container; with pressure-indicating gage.
8. Regular Dry-Chemical Type: UL-rated <**Insert capacity**> nominal capacity, with sodium bicarbonate-based dry chemical in manufacturer's standard enameled container.
9. Regular Dry-Chemical Type in Steel Container: UL-rated 2-B:C, 1-lb (0.4-kg) **OR** 10-B:C, 2.5-lb (1.1-kg) **OR** 10-B:C, 5-lb (2.3-kg) **OR** 40-B:C, 5.5-lb (2.5-kg) **OR** 40-B:C, 6-lb (2.7-kg) **OR** 60-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in enameled-steel container.
10. Regular Dry-Chemical Type in Aluminum Container: UL-rated 2-B:C, 1-lb (0.4-kg) **OR** 10-B:C, 2.5-lb (1.1-kg) **OR** 10-B:C, 5-lb (2.3-kg) **OR** 40-B:C, 5.5-lb (2.5-kg) **OR** 60-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in enameled-aluminum container.
11. Regular Dry-Chemical Type in Brass Container: UL-rated 40-B:C, 6-lb (2.7-kg) **OR** 60-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in chrome-plated brass container.
12. Multipurpose Dry-Chemical Type: UL-rated <**Insert capacity**> nominal capacity, with monoammonium phosphate-based dry chemical in manufacturer's standard enameled container.
13. Multipurpose Dry-Chemical Type in Steel Container: UL-rated 1-A:10-B:C, 2.5-lb (1.1-kg) **OR** 2-A:10-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 6-lb (2.7-kg) **OR** 4-A:60-B:C, 10-lb (4.5-kg) **OR** 20-A:120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in enameled-steel container.
14. Multipurpose Dry-Chemical Type in Aluminum Container: UL-rated 1-A:10-B:C, 2.5-lb (1.1-kg) **OR** 2-A:10-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 6-lb (2.7-kg) **OR** 4-A:60-B:C, 10-lb (4.5-kg) **OR** 20-A:120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in enameled-aluminum container.
15. Multipurpose Dry-Chemical Type in Brass Container: UL-rated 2-A:10-B:C, 5-lb (2.3-kg) **OR** 3-A:40-B:C, 6-lb (2.7-kg) **OR** 4-A:60-B:C, 10-lb (4.5-kg) **OR** 4-A:80-B:C, 10-lb (4.5-kg) **OR** 20-A:120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in chrome-plated brass container.
16. Purple-K Dry-Chemical Type in Aluminum Container: UL-rated 10-B:C, 2.5-lb (1.1-kg) **OR** 30-B:C, 5-lb (2.3-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with potassium bicarbonate-based dry chemical in enameled-aluminum container.
17. Purple-K Dry-Chemical Type in Brass Container: UL-rated 80-B:C, 10-lb (4.5-kg) **OR** 120-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with potassium bicarbonate-based dry chemical in chrome-plated brass container.
18. Carbon Dioxide Type: UL-rated 5-B:C, 5-lb (2.3-kg) **OR** 10-B:C, 10-lb (4.5-kg) **OR** 10-B:C, 15-lb (6.8-kg) **OR** 10-B:C, 20-lb (9.1-kg), **as directed**, nominal capacity, with carbon dioxide in manufacturer's standard enameled-metal **OR** enameled-steel **OR** enameled-aluminum, ,**as directed** container.
19. Dry-Powder Type: FMG-approved, **as directed**, UL-rated Class D, 30-lb (13.6-kg) nominal capacity, with sodium chloride-based **OR** copper-based, **as directed**, powder in enameled-steel container; with pressure-indicating gage.
20. Halon Type: UL-rated 5-B:C, 2.5-lb (1.1-kg) **OR** 10-B:C, 5-lb (2.3-kg), **as directed**, nominal capacity, in enameled-steel container; with pressure-indicating gage.
21. Clean-Agent Type in Aluminum Container: UL-rated 1-B:C, 1.4-lb (0.6-kg) **OR** 2-B:C, 2.5-lb (1.1-kg) **OR** 5-B:C, 5-lb (2.3-kg), **as directed**, nominal capacity, with HCFC Blend B agent and inert material in enameled-aluminum container; with pressure-indicating gage.

22. Clean-Agent Type in Brass Container: UL-rated 1-A:10-B:C, 11-lb (5-kg) **OR** 2-A:10-B:C, 15.5-lb (7-kg), **as directed**, nominal capacity, with HCFC Blend B agent and inert material in chrome-plated brass container; with pressure-indicating gage.
23. Clean-Agent Type in Steel Container: UL-rated 5-B:C, 4.75-lb (2.2-kg) **OR** 1-A:10-B:C, 10-lb (4.5-kg) **OR** 2-A:10-B:C, 14-lb (6.4-kg), **as directed**, nominal capacity, with HFC blend agent and inert material in enameled-steel container; with pressure-indicating gage.

B. Mounting Brackets
1. Mounting Brackets: Manufacturer's standard galvanized, **as directed**, steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or red **OR** black, **as directed**, baked-enamel finish.
2. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location.
   a. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.
      1) Orientation: Vertical **OR** Horizontal, **as directed**.

C. Wheeled Fire Extinguishers
1. Wheeled Fire Extinguishers: Type, size, and capacity for locations indicated, complete with carriage.
   a. Carriage: Fabricated from enameled-steel pipe, complete with hanger assembly, long-range nozzle, hose, and semipneumatic solid-rubber tires **OR** wide-rim wheels, **as directed**.
      1) Hose: 15 feet (4.6 m) **OR** 50 feet (15.2 m) **OR** 100 feet (30.5 m), **as directed**.
2. Pressurized, FFFP-Foam Type: UL-rated 20-A:160-B, 33-gal. (125-L) nominal capacity, with FFFP foam in stainless-steel container.
3. Regular Dry-Chemical Type: UL-rated 160-B:C, 50-lb (23-kg) **OR** 240-B:C, 150-lb (68-kg) **OR** 160-B:C, 250-lb (113-kg), **as directed**, nominal capacity, with sodium bicarbonate-based dry chemical in regulated-pressure **OR** stored-pressure **OR** direct-pressure, **as directed**, enameled-steel container.
4. Multipurpose Dry-Chemical Type: UL-rated 20-A:160-B:C, 30-lb (13.6-kg) **OR** 30-A:160-B:C, 50-lb (23-kg) **OR** 40-A:240-B:C, 125-lb (57-kg) **OR** 40-A:160-B:C, 250-lb (113-kg), **as directed**, nominal capacity, with monoammonium phosphate-based dry chemical in regulated-pressure **OR** stored-pressure **OR** direct-pressure, **as directed**, enameled-steel **OR** enameled-aluminum, **as directed**, container.
5. Purple-K Dry-Chemical Type: UL-rated 160-B:C, 50-lb (23-kg) **OR** 320-B:C, 125-lb (57-kg) **OR** 160-B:C, 250-lb (113-kg), **as directed**, nominal capacity, with potassium bicarbonate-based dry chemical in regulated-pressure **OR** stored-pressure **OR** direct-pressure, **as directed**, enameled-steel container.
6. Carbon Dioxide Type: UL-rated 20-B:C, 50-lb (23-kg) **OR** 20-B:C, 100-lb (45-kg), **as directed**, nominal capacity, with carbon dioxide in manufacturer's standard enameled-metal **OR** enameled-steel **OR** enameled-aluminum, **as directed**, container.
7. Dry-Powder Type: FMG-approved, **as directed**, UL-rated Class D, sodium chloride-based powder, 150-lb (68-kg) **OR** copper-based powder, 250-lb (113-kg), **as directed**, nominal capacity, in regulated-pressure, enameled-steel container; with pressure-indicating gage.
8. Clean-Agent Type: UL-rated 4-A:40-B:C, 65-lb (29-kg) **OR** 10-A:80-B:C, 150-lb (68-kg), **as directed**, nominal capacity, with HCFC Blend B agent and inert material in stored-pressure, enameled-steel container; with pressure-indicating gage.

1.3 EXECUTION

A. Installation
1. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

a. Mounting Brackets: 54 inches (1372 mm) above finished floor to top of fire extinguisher. If NFPA 10 is the governing code, maximum mounting height for fire extinguishers weighing 40 lb (18 kg) or less shall be 60 inches (1524 mm); for those weighing more, maximum mounting height shall be 42 inches (1067 mm).

2. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

END OF SECTION 10522

Task	Specification	Specification Description
10522	01352	No Specification Required

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SECTION 10605 - WIRE MESH PARTITIONS

1.1 GENERAL

A. Description Of Work:
1. This specification covers the furnishing and installation of materials for wire mesh partitions. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Standard-duty wire mesh partitions.
b. Heavy-duty wire mesh partitions.
c. Wire mesh ceilings.
d. Wire mesh storage lockers.
e. Wire mesh stairway partitions.
f. Wire mesh equipment barriers.

C. Definitions
1. As defined in ASTM E 2016:
a. Intermediate Crimp: Wires pass over one and under the next adjacent wire in both directions, with wires crimped before weaving and with extra crimps between the intersections.
b. Lock Crimp: Deep crimps at points of the intersection that lock wires securely in place.

D. Performance Requirements
1. Delegated Design: Design wire mesh units, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Wire mesh units shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.
3. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.
a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
3. Samples: For each exposed product and for each color and texture specified.
4. Delegated-Design Submittal: For wire mesh units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Maintenance data.

F. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. AWS D1.3, "Structural Welding Code - Sheet Steel."
2. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Deliver wire mesh items with cardboard protectors on perimeters of panels and doors and with posts wrapped **OR** palleted **OR** crated, **as directed**, to provide protection during transit and Project-site storage. Use vented plastic.
2. Inventory wire mesh partition door hardware on receipt and provide secure lockup for wire mesh partition door hardware delivered to Project site.
   a. Tag each item or package separately with identification and include basic installation instructions with each item or package.
3. Deliver keys to Owner by registered mail or overnight package service.

1.2 PRODUCTS

A. Materials
1. Steel Wire: ASTM A 510 (ASTM A 510M).
2. Steel Plates, Channels, Angles, and Bars: ASTM A 36/A 36M.
3. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B.
4. Steel Pipe: ASTM A 53/A 53M, Schedule 40 unless another weight is indicated or required by structural loads.
5. Square Steel Tubing: ASTM A 500, cold-formed structural-steel tubing.
6. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with G60 (Z180) zinc (galvanized) or A60 (ZF180) zinc-iron-alloy (galvannealed) coating designation.
7. Panel-to-Panel Fasteners: Manufacturer's standard steel bolts, nuts, and washers.
8. Postinstalled Expansion Anchors: With capability to sustain, without failure, load imposed within factors of safety indicated, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
   a. Carbon Steel: Zinc plated to comply with ASTM B 633, Class Fe/Zn 5 (0.005 mm) for Class SC 1 service condition (mild).
   b. Stainless Steel: ASTM F 593 and ASTM F 594, Alloy Group 1 or 2 (ASTM F 738M and ASTM F 836M, Alloy Group 1 or 4), for bolts and nuts; ASTM A 276 or ASTM A 666, Type 304 or 316, for anchors.
   c. For Postinstalled Anchors in Concrete: Capability to sustain, without failure, a load equal to four times the loads imposed.
   d. For Postinstalled Anchors in Grouted Masonry Units: Capability to sustain, without failure, a load equal to six times the loads imposed.
9. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated and fabricated from corrosion-resistant materials; with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by wire mesh construction, as determined by testing per ASTM E 1190, conducted by a qualified testing and inspecting agency.
10. Seismic Bracing: Angles with legs not less than 1-1/4 inch (32 mm) wide, formed from 0.04-inch- (1-mm-) thick, metallic-coated steel sheet; with bolted connections and 1/4-inch- (6-mm-) diameter bolts.
11. Shop Primers: Provide primers that comply with Division 07..
12. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer, complying with MPI#79.
    a. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
13. Zinc-Rich Primer: Compatible with topcoat, complying with SSPC-Paint 20 or SSPC-Paint 29.
14. Galvanizing Repair Paint: High-zinc-dust-content paint for regalvanizing welds in steel, complying with SSPC-Paint 20.

B. Standard-Duty Wire Mesh Partitions
1. Mesh: 0.135-inch- (3.5-mm-) diameter, intermediate-crimp steel wire woven into 1-1/2-inch (38-mm) diamond mesh.

2. Vertical Panel Framing: 1-1/4-by-5/8-by-0.097-inch (32-by-16-by-2.5-mm) cold-rolled, C-shaped steel channels with 1/4-inch- (6-mm-) diameter bolt holes spaced not more than 18 inches (450 mm) o.c. along center of framing.
3. Horizontal and Vertical Panel Framing: 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) cold-rolled steel channels.
4. Horizontal Panel Stiffeners: 2 cold-rolled steel channels, not less than 1 by 3/8 by 1/8 inch (25 by 9.5 by 3 mm), bolted or riveted toe to toe through mesh or 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) cold-rolled steel channels with wire woven through.
5. Top Capping Bars: 2-1/4-by-1-inch (57-by-25-mm) cold-rolled steel channels.
6. Posts for 90-Degree Corners: 1-1/4-by-1-1/4-by-1/8-inch (32-by-32-by-3-mm) steel angles with 1/4-inch- (6-mm-) diameter bolt holes aligning with bolt holes in vertical framing; with floor anchor clips.
7. Posts for Other-Than-90-Degree Corners: Manufacturer's standard steel pipe or tubing with 1/4-inch- (6-mm-) diameter bolt holes aligning with bolt holes in vertical framing.
   a. Partitions up to 12 Feet (3.7 m) High: 1-1/4-inch (32-mm) OD.
   b. Partitions up to 20 Feet (6.1 m) High: 2-1/2-inch (65-mm) OD.
8. Adjustable Corner Posts: 2, manufacturer's standard steel pipe or tubing posts connected by steel hinges at 36 inches (900 mm) o.c. attached to posts; with 1/4-inch- (6-mm-) diameter bolt holes aligning with bolt holes in vertical framing.
9. Line Posts: 3-inch-by-4.1-lb (76-mm-by-1.9-kg) or 3-1/2-by-1-1/4-by-0.127-inch (89-by-32-by-3.2-mm) steel channels; with 5-by-18-by-1/4-inch (125-by-450-by-6-mm) steel base plates punched for attachment to floor.
10. Three- and Four-Way Intersection Posts: 1-1/4-by-1-1/4-inch (32-by-32-mm) tubular steel, with 1/4-inch- (6-mm-) diameter bolt holes aligned for bolting to adjacent panels.
11. Floor Shoes: Steel, cast iron, or cast aluminum, not less than 2 inches (50 mm) high; sized to suit vertical framing, drilled for attachment to floor, and with set screws for leveling adjustment.
12. Swinging Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/4-by-1/2-by-1/8-inch (32-by-13-by-3-mm) steel channels or C-channels, banded with 1-1/4-by-1/8-inch (32-by-3-mm) flat steel bar cover plates on 3 **OR** 4, **as directed**, sides, and with 1/8-inch- (3-mm-) thick angle strike bar and cover on strike jamb.
   a. Hinges: Full-surface type, 3-by-3-inch (76-by-76-mm) steel, 1-1/2 pairs per door; bolted, riveted, or welded to door and jamb framing.
   b. Padlock Lug: Mortised into door framing and enclosed with steel cover.
   c. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.
   d. Inactive Leaf Hardware: Cane bolt at bottom and chain bolt at top.
13. Swinging Dutch Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/4-by-1/2-by-1/8-inch (32-by-13-by-3-mm) steel channels or C-channels, banded with 1-1/4-by-1/8-inch (32-by-3-mm) flat steel bar cover plates on 3 **OR** 4, **as directed**, sides, and with 1/8-inch- (3-mm-) thick angle strike bar and cover on strike jamb.
   a. Hinges: Full-surface type, 3-by-3-inch (76-by-76-mm) steel, 1 pair per section of door (top and bottom); bolted, riveted, or welded to door and jamb framing.
   b. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside; mounted in lower section of door.
   c. Bolt: Mounted in, securing upper section of door.
   d. Shelf: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet, 12 inches (300 mm) deep by full width of door; with corners rounded and edges finished smooth; mounted on top of lower section of door and braced with manufacturer's standard brackets.
14. Sliding Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) steel channels or C-channels, banded with 1-1/2-by-1/8-inch (38-by-3-mm) flat steel bar cover plates on 4 sides.
   a. Hardware: Two, four-wheel roller-bearing carriers, box track, and bottom guide channel for each door.
   b. Padlock Lug: Mortised into door framing and enclosed with steel cover.

c. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.

15. Vertically Sliding Service Windows: Fabricated from same mesh and framing as panels and equipped with spring catch **OR** slide bolts, **as directed**, on each jamb that locks window in open and closed positions. Include opening frame in partition fabricated from 1-1/4-by-1/2-by-1/8-inch (32-by-13-by-3-mm) steel channels or C-channels.
    a. Size: 24 inches wide by 18 inches high (600 mm wide by 450 mm high) **as directed** As indicated, **as directed**.
    b. Shelf: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet; with corners rounded and edges finished smooth; braced with manufacturer's standard brackets.
        1) Size: 24 inches wide by 12 inches deep (600 mm wide by 300 mm deep) **OR** As indicated, **as directed**.
16. Swinging Service Windows: Fabricated from same mesh and framing as panels and equipped with spring catch on strike jamb that locks window in closed position. Include opening frame in partition fabricated from 1-1/4-by-1/2-by-1/8-inch (32-by-13-by-3-mm) steel channels or C-channels.
    a. Size: 24 inches wide by 18 inches high (600 mm wide by 450 mm high) **OR** As indicated, **as directed**.
    b. Shelf: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet; with corners rounded and edges finished smooth; braced with manufacturer's standard brackets.
        1) Size: 24 inches wide by 12 inches deep (600 mm wide by 300 mm deep) **OR** As indicated, **as directed**.
17. Accessories:
    a. Sheet Metal Base: Not less than 0.060-inch- (1.5-mm-) thick, cold-rolled steel sheet.
    b. Adjustable Filler Panels: Not less than 0.060-inch- (1.5-mm-) thick, cold-rolled steel sheet; capable of filling openings from 2 to 12 inches (50 to 300 mm).
    c. Wall Clips: Manufacturer's standard, cold-rolled steel sheet; allowing up to 1 inch (25 mm) of adjustment, **as directed**.
18. Finish for Uncoated Ferrous Steel: Hot-dip galvanized **OR** Hot-dip galvanized and shop primed for field painting **OR** Shop primed for field painting **OR** Shop coat **OR** Baked-enamel finish **OR** Powder-coated finish, **as directed**, unless otherwise indicated.
    a. Color: As selected from manufacturer's full range.

C. Heavy-Duty Wire Mesh Partitions
1. Mesh: 0.192-inch- (4.8-mm-) diameter, intermediate-crimp steel wire woven into 2-inch (50-mm) diamond mesh.
2. Vertical and Horizontal Panel Framing: 1-1/2-by-3/4-by-0.097-inch (38-by-19-by-2.5-mm) cold-rolled, C-shaped steel channels; with 3/8-inch- (9.5-mm-) diameter bolt holes spaced not more than 18 inches (450 mm) o.c. along center of framing.
3. Vertical and Horizontal Panel Framing: 1-1/2-by-3/4-by-1/4-inch (38-by-19-by-6-mm) cold-rolled steel channels; with 3/8-inch- (9.5-mm-) diameter bolt holes spaced not more than 18 inches (450 mm) o.c. along center of framing. Provide vertical panel stiffeners in shapes and sizes as recommended by manufacturers.
4. Horizontal Panel Stiffeners: 2 cold-rolled steel channels, not less than 1 by 1/2 by 1/8 inch (25 by 13 by 3 mm), bolted or riveted toe to toe through mesh or 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) cold-rolled steel channels with wire woven through.
5. Top Capping Bars: 3-inch-by-4.1-lb (76-mm-by-1.9-kg) hot-rolled steel channels.
6. Posts for 90-Degree Corners: 2-by-2-by-1/8-inch (50-by-50-by-3-mm) steel angles with 3/8-inch- (9.5-mm-) diameter bolt holes aligning with bolt holes in vertical framing; with floor anchor clips.
7. Posts for Other-Than-90-Degree Corners: Manufacturer's standard steel 2-inch- (50-mm) OD pipe or tubing with 3/8-inch- (9.5-mm-) diameter bolt holes aligning with bolt holes in vertical framing.

8. Adjustable Corner Posts: 2, manufacturer's standard steel pipe or tubing posts connected by steel hinges at 36 inches (900 mm) o.c. attached to posts; with 1/4-inch- (6-mm-) diameter bolt holes aligning with bolt holes in vertical framing.
9. Line Posts: 3-inch-by-4.1-lb (76-mm-by-1.9-kg) or 3-1/2-by-1-1/4-by-0.1265-inch (89-by-32-by-3.2-mm) steel channels; with 5-by-18-by-1/4-inch (125-by-450-by-6-mm) steel base plates punched for attachment to floor.
10. Three- and Four-Way Intersection Posts: 2-by-2-inch (50-by-50-mm) tubular steel, with 3/8-inch-(9.5-mm-) diameter bolt holes aligned for bolting to adjacent panels.
11. Floor Shoes: Steel, cast iron, or cast aluminum, not less than 2 inches (50 mm) high; sized to suit vertical framing, drilled for attachment to floor, and with set screws for leveling adjustment.
12. Swinging Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) steel channels or C-channels, banded with 1-1/2-by-1/8-inch (38-by-3-mm) flat steel bar cover plates on 4 sides, and with 1/8-inch- (3-mm-) thick angle strike bar and cover on strike jamb.
    a. Hinges: Full-surface type, 3-1/2-by-3-1/2-inch (89-by-89-mm) steel, 1-1/2 pairs per door; bolted, riveted, or welded to door and jamb framing.
    b. Padlock Lug: Mortised into door framing and enclosed with steel cover.
    c. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.
    d. Inactive Leaf Hardware: Cane bolt at bottom and chain bolt at top.
13. Swinging Dutch Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) steel channels or C-channels, banded with 1-1/2-by-1/8-inch (38-by-3-mm) flat steel bar cover plates on 3 **OR** 4, **as directed**, sides, and with 1/8-inch- (3-mm-) thick angle strike bar and cover on strike jamb.
    a. Hinges: Full-surface type, 3-1/2-by-3-1/2-inch (89-by-89-mm) steel, 1 pair per section of door (top and bottom); bolted, riveted, or welded to door and jamb framing.
    b. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.
    c. Bolt: Mounted in, securing upper section of door.
    d. Shelf: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet, 12 inches (300 mm) deep by full width of door; with corners rounded and edges finished smooth; mounted on top of lower section of door and braced with manufacturer's standard brackets.
14. Sliding Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) steel channels or C-channels, banded with 1-1/2-by-1/8-inch (38-by-3-mm) flat steel bar cover plates on 4 sides.
    a. Hardware: Two, four-wheel roller-bearing carriers, box track, and bottom guide channel for each door.
    b. Padlock Lug: Mortised into door framing and enclosed with steel cover.
    c. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.
15. Vertically Sliding Service Windows: Fabricated from same mesh and framing as panels and equipped with spring catch **OR** slide bolts, **as directed**, on each jamb that locks window in open and closed positions. Include opening frame in partition fabricated from 1-1/4-by-1/2-by-1/8-inch (32-by-13-by-3-mm) steel channels or C-channels.
    a. Size: 24 inches wide by 18 inches high (600 mm wide by 450 mm high) **OR** As indicated, **as directed**.
    b. Shelf: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet; with corners rounded and edges finished smooth; braced with manufacturer's standard brackets.
        1) Size: 24 inches wide by 12 inches deep (600 mm wide by 300 mm deep) **OR** As indicated, **as directed**.
16. Swinging Service Windows: Fabricated from same mesh and framing as panels and equipped with spring catch on strike jamb that locks window in closed position. Include opening frame in

partition fabricated from 1-1/4-by-1/2-by-1/8-inch (32-by-13-by-3-mm) steel channels or C-channels.

a. Size: 24 inches wide by 18 inches high (600 mm wide by 450 mm high) **OR** As indicated, **as directed**.

b. Shelf: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet; with corners rounded and edges finished smooth; braced with manufacturer's standard brackets.

1) Size: 24 inches wide by 12 inches deep (600 mm wide by 300 mm deep) **OR** As indicated, **as directed**.

17. Accessories:

a. Sheet Metal Base: Not less than 0.060-inch- (1.5-mm-) thick, cold-rolled steel sheet.

b. Adjustable Filler Panels: Not less than 0.0598-inch- (1.5-mm-) thick, cold-rolled steel sheet; capable of filling openings from 2 to 12 inches (50 to 300 mm).

c. Wall Clips: Manufacturer's standard, cold-rolled steel sheet; allowing up to 1 inch (25 mm) of adjustment, **as directed**.

18. Finish for Uncoated Ferrous Steel: Hot-dip galvanized **OR** Hot-dip galvanized and shop primed for field painting **OR** Shop primed for field painting **OR** Shop coat **OR** Baked-enamel finish **OR** Powder-coated finish, **as directed**, unless otherwise indicated.

a. Color: As selected from manufacturer's full range.

D. Wire Mesh Ceilings

1. Mesh, Framing, and Stiffeners: Fabricated from same mesh and framing as wire mesh partition panels.
2. Perimeter Partition Supports: 1-1/2-by-1-1/2-by-1/8-inch (38-by-38-by-3-mm) steel angle, with 1/4-inch- (6-mm-) diameter bolt holes aligned for bolting to top of wire mesh partitions and to sides of wire mesh ceiling panels.
3. Wall Supports: 1-1/2-by-1-1/2-by-1/8-inch (38-by-38-by-3-mm) steel angle punched for attachment to wall and wire mesh ceiling panels.
4. Intermediate Supports: Steel I-beam, as recommended by manufacturer.
5. Intermediate Support Posts: 2-by-2-by-1/8-inch (50-by-50-by-3-mm) steel pipe or tubing.
6. Finishes: Match adjacent wire mesh partitions.

E. Wire Mesh Storage Lockers

1. Unit Sizes:

a. Width: 36 inches (914 mm) **OR** 48 inches (1219 mm), **as directed**.

b. Depth: 36 inches (914 mm) **OR** 48 inches (1219 mm) **OR** 60 inches (1524 mm), **as directed**.

c. Height: 90 inches (2286 mm).

2. Mesh: 0.135-inch- (3.5-mm-) diameter, intermediate-crimp steel wire woven into 1-1/2-inch (38-mm) diamond **OR** 1-by-2-inch (25-by-50-mm) rectangular, **as directed**, mesh.
3. Wall Panels: 1-1/4-by-1-1/4-by-1/8-inch (32-by-32-by-3-mm) steel angle framing on top, bottom, and back sides, and 3-by-1/8-inch (76-by-3-mm) cold-rolled steel flat bar framing on front side; with wire mesh welded to framing.

a. Horizontal Panel Stiffeners: 1-1/4-by-1-1/4-by-1/8-inch (32-by-32-by-3-mm) steel angles or 3/4-by-1/4-inch (19-by-6-mm) hot-rolled steel flat bars.

4. Backs: 0.027-inch- (0.7-mm-) thick, metallic-coated steel sheet.
5. Tops: Fabricated from same mesh and framing as doors **OR** 0.027-inch- (0.7-mm-) thick, metallic-coated steel sheet, **as directed**.
6. Horizontal Dividers/Shelves: 0.043-inch- (1.1-mm-) thick, metallic-coated, **as directed**, steel sheet; with flanged edges and reinforced across width with 3/4-by-1/4-inch (19-by-6-mm) steel stiffeners, **as directed**.
7. Doors: Fabricated from same mesh as wall panels, with framing fabricated from 1-1/4-by-1-1/4-by-1/8-inch (32-by-32-by-3-mm) steel angles on 4 sides; with wire mesh welded to framing. Include door strike and padlock hasp.

a. Horizontal Stiffeners for Single-Tier Doors: 3/4-by-1/4-inch (19-by-6-mm) steel flat bars.

b. Hinges: Full-surface type, 2-1/2-by-2-1/2-inch (64-by-64-mm) steel, 1-1/2 pairs per single-tier door and 1 pair per double-tier door; bolted, riveted, or welded to door and jamb framing.

8. Finish for Uncoated Ferrous Steel: Hot-dip galvanized **OR** Hot-dip galvanized and shop primed for field painting **OR** Shop primed for field painting **OR** Shop coat **OR** Baked-enamel finish **OR** Powder-coated finish, **as directed**, unless otherwise indicated.
   a. Color: As selected from manufacturer's full range.

F. Wire Mesh Stairway Partitions
1. Standard-Duty Stairway Partitions:
   a. Diamond Mesh: 0.135-inch- (3.5-mm-) diameter, intermediate-crimp steel wire woven into 1-1/2-inch (38-mm) diamond pattern and securely clinched to frames.
   b. Square Mesh: 0.135-inch- (3.5-mm-) diameter, intermediate **OR** lock, **as directed**,-crimp steel wire woven into 1-1/2-inch (38-mm) square pattern, inserted through frame holes and welded into frame. Vertical wires are plumb, and horizontal wires are perpendicular to vertical wires.
   c. Rectangular Mesh: 0.135-inch- (3.5-mm-) diameter, intermediate **OR** lock, **as directed**,-crimp steel wire woven into 2-by-1-inch (50-by-25-mm) rectangular pattern, inserted through frame holes and welded into frame. Vertical wires are plumb, and horizontal wires are perpendicular to vertical wires.
   d. Vertical Panel Framing: 1-1/4-by-5/8-by-0.0966-inch (32-by-16-by-2.5-mm) cold-rolled, C-shaped steel channels; with 1/4-inch- (6-mm-) diameter bolt holes spaced not more than 18 inches (450 mm) o.c. along center of framing.
   e. Horizontal Panel Framing: 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) cold-rolled steel channels.
   f. Horizontal Panel Stiffeners: 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) cold-rolled steel channels with wire woven through, or two 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) cold-rolled steel channels bolted or riveted toe to toe through mesh.
2. Heavy-Duty Stairway Partitions:
   a. Diamond Mesh: 0.192-inch- (4.9-mm-) diameter, intermediate-crimp steel wire woven into 2-inch (50-mm) diamond pattern and securely clinched to frames.
   b. Square Mesh: 0.192-inch- (4.9-mm-) diameter, intermediate **OR** lock, **as directed**,-crimp steel wire woven into 2-inch (50-mm) square pattern, inserted through frame holes and welded into frame. Vertical wires are plumb, and horizontal wires are perpendicular to vertical wires.
   c. Rectangular Mesh: 0.192-inch- (4.9-mm-) diameter, intermediate **OR** lock, **as directed**,-crimp steel wire woven into 2-by-1-inch (50-by-25-mm) rectangular pattern, inserted through frame holes and welded into frame. Vertical wires are plumb, and horizontal wires are perpendicular to vertical wires.
   d. Vertical and Horizontal Panel Framing: 1-1/2-by-3/4-by-0.0966-inch (38-by-19-by-2.5-mm) cold-rolled, C-shaped steel channels; with 3/8-inch- (9.5-mm-) diameter bolt holes spaced not more than 18 inches (450 mm) o.c. along center of framing.
   e. Horizontal Panel Stiffeners: 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) cold-rolled steel channels with wire woven through, or two 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) cold-rolled steel channels bolted or riveted toe to toe through mesh.
3. Swinging Doors: Fabricated from same mesh as partitions, with framing fabricated from 1-1/2-by-3/4-by-1/8-inch (38-by-19-by-3-mm) steel channels, banded with 1-1/2-by-1/8-inch (38-by-3-mm) flat steel bar cover plates on 3 **OR** 4, **as directed**, sides, and with 1/8-inch- (3-mm-) thick angle strike bar and cover on strike jamb.
   a. Hinges: Full-surface spring type, 3-1/2-by-3-1/2-inch (89-by-89-mm) steel, 1-1/2 pairs per door; bolted, riveted, or welded to door and jamb framing.
   b. Exit Device: As specified in Division 08 Section "Door Hardware".
   c. Tamper Shield: Fabricated from 0.097-inch- (2.5-mm-) thick, cold-rolled steel sheet; 15 inches (381 mm) high by width of door.
4. Door Jamb Framing: 2-by-2-by-1/8-inch (50-by-50-by-3-mm) steel pipe or tubing.

5. Floor Shoes: Steel, cast iron, or cast aluminum, not less than 2 inches (50 mm) high; sized to suit vertical framing, drilled for attachment to floor, and with set screws for leveling adjustment.
6. Wall Clips: Manufacturer's standard, cold-rolled steel sheet; allowing up to 1 inch (25 mm) of adjustment, **as directed**.
7. Finish for Uncoated Ferrous Steel: Hot-dip galvanized **OR** Hot-dip galvanized and shop primed for field painting **OR** Shop primed for field painting **OR** Shop coat **OR** Baked-enamel finish **OR** Powder-coated finish, **as directed**, unless otherwise indicated.
   a. Color: As selected from manufacturer's full range.

G. Wire Mesh Equipment Barriers
1. Mesh: 0.135-inch- (3.5-mm-) diameter, intermediate-crimp steel wire woven into 1-1/2-inch (38-mm) diamond **OR** 1-by-2-inch (25-by-50-mm) rectangular, **as directed**, mesh.
2. Panels: 1-1/4-by-1-1/4-by-1/8-inch (32-by-32-by-3-mm) steel angle framing on 4 sides, with wire mesh welded to framing.
   a. Horizontal Panel Stiffeners: 1-1/4-by-1-1/4-by-1/8-inch (32-by-32-by-3-mm) steel angles or 3/4-by-1/4-inch (19-by-6-mm) hot-rolled steel flat bars.
   b. Height: 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**.
3. Line and Corner Posts: 2-by-2-by-0.068-inch (50-by-50-by-1.7-mm) steel tubing with steel base plates welded to bottoms, drilled for attachment to floor, and with steel caps welded to tops.
   a. Height: Panel height plus 12-inch- (300-mm-), **as directed**, high, sweep space.
4. Swinging Gates: Fabricated from same mesh as panels, with gate framing fabricated from 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-4.7-mm) steel angles on 4 sides, and with wire mesh welded to framing.
   a. Hinges: Full-surface spring, **as directed**, type, 3-1/2-by-3-1/2-inch (89-by-89-mm) steel, 1 pair per door; bolted, riveted, or welded to door and jamb framing.
   b. Padlock Lug: Mortised into door framing and enclosed with steel cover.
   c. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.
5. Sliding Gates: Fabricated from same mesh as panels, with framing fabricated from 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-4.7-mm) steel angles on 4 sides, and with wire mesh welded to framing.
   a. Hardware: Two, four-wheel roller-bearing carriers, box track, and bottom guide channel for each door.
   b. Padlock Lug: Mortised into door framing and enclosed with steel cover.
   c. Cylinder Lock: Mortise type with manufacturer's standard cylinder **OR** cylinder specified in Division 08 Section "Door Hardware", **as directed**; operated by key outside and recessed turn knob **OR** knob **OR** lever, **as directed**, inside.
6. Finish for Uncoated Ferrous Steel: Hot-dip galvanized **OR** Hot-dip galvanized and shop primed for field painting **OR** Shop primed for field painting **OR** Shop coat **OR** Baked-enamel finish **OR** Powder-coated finish, **as directed**, unless otherwise indicated.
   a. Color: As selected from manufacturer's full range.

H. Fabrication
1. General: Fabricate wire mesh items from components of sizes not less than those indicated. Use larger-sized components as recommended by wire mesh item manufacturer. As required for complete installation, provide bolts, hardware, and accessories with manufacturer's standard finishes.
   a. Fabricate wire mesh items to be readily disassembled.
   b. Welding: Weld corner joints of framing and grind smooth, leaving no evidence of joint **OR** finish sand **OR** remove spatter **OR** leave as applied, **as directed**.
2. Standard- and Heavy-Duty Wire Mesh Partitions: Fabricate wire mesh partitions with cutouts for pipes, ducts, beams, and other items indicated. Finish edges of cutouts to provide a neat, protective edge.
   a. Mesh: Securely clinch mesh to framing.

b. Framing: Fabricate framing with mortise and tenon corner construction.
   1) Provide horizontal stiffeners as indicated or, if not indicated, as required by panel height and as recommended by wire mesh partition manufacturer. Weld horizontal stiffeners to vertical framing.
   2) Fabricate three- and four-way intersections using intersection posts **OR** manufacturer's standard connecting clips and fasteners, **as directed**.
   3) Fabricate partition and door framing with slotted holes for connecting adjacent panels.
c. Fabricate wire mesh partitions with 3 inches (76 mm) of clear space between finished floor and bottom horizontal framing.
d. Fabricate wire mesh partitions with bottom horizontal framing flush with finished floor.
e. Doors: Align bottom of door with bottom of adjacent panels.
   1) For doors that do not extend full height of partition, provide transom over door, fabricated from same mesh and framing as partition panels.
f. Hardware Preparation: Mortise, reinforce, drill, and tap doors and framing as required to install hardware.

3. Wire Mesh Ceilings: Fabricate wire mesh partitions with cutouts for pipes, ducts, beams, and other items indicated. Finish edges of cutouts to provide a neat, protective edge.
   a. Mesh: Securely clinch mesh to framing.
   b. Framing: Fabricate framing with mortise and tenon corner construction.
      1) Provide stiffeners as indicated or, if not indicated, as required by panel span and as recommended by wire mesh ceiling manufacturer. Weld stiffeners to framing.
4. Wire Mesh Stairway Partitions: Provide door jamb framing on each side of doors. Attach tamper shields centered behind exit devices.
5. Wire Mesh Storage Lockers: Fabricate initial storage locker with front and two sides. Fabricate additional storage lockers similarly, so each unit is independent **OR** as add-on units, designed to share one side with initial storage locker, **as directed**.
   a. Fabricate wall panel and door framing with slotted holes for connecting adjacent panels.
   b. Prehang doors in factory.

I. General Finish Requirements
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

J. Steel And Iron Finishes
1. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:
   a. ASTM A 123/A 123M, for galvanizing steel and iron components.
   b. ASTM A 153/A 153M, for galvanizing steel and iron hardware.
   c. Preparation for Shop Priming: After galvanizing, thoroughly clean wire mesh components of grease, dirt, oil, flux, and other foreign matter, and treat with metallic-phosphate process.
2. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface-preparation specifications and environmental exposure conditions of installed metal fabrications:
   a. Exteriors (SSPC Zone 1B) and Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."
   b. Interiors (SSPC Zone 1A): SSPC-SP 3, "Power Tool Cleaning."
3. Shop Priming: Apply shop primer to uncoated surfaces of metal fabrications, except those with galvanized finishes and those to be embedded in concrete or masonry, unless otherwise indicated. Comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
   a. Stripe paint corners, crevices, bolts, welds, and sharp edges.

4. Shop Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard one-coat, shop-coat finish suitable for use intended. Comply with paint manufacturer's written instructions for applying and curing.
   a. Color and Gloss: As selected from manufacturer's full range.
5. Baked-Enamel or Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard 2-coat, baked-on finish, suitable for use indicated, consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat.
   a. Color and Gloss: As selected from manufacturer's full range.

1.3 EXECUTION

A. Wire Mesh Partitions Erection
1. Anchor wire mesh partitions to floor with 3/8-inch- (9.5-mm-) diameter, postinstalled expansion anchors at 12 inches (305 mm) o.c. through anchor clips located at each post and corner. Shim anchor clips as required to achieve level and plumb installation.
2. Anchor wire mesh partitions to floor with 3/8-inch- (9.5-mm-) diameter, postinstalled expansion anchors at 12 inches (305 mm) o.c. through floor shoes located at each post and corner. Adjust wire mesh partition posts in floor shoes to achieve level and plumb installation.
3. Anchor wire mesh partitions to walls at 12 inches (305 mm) o.c. through back corner panel framing and as follows:
   a. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
   b. For hollow masonry anchorage, use toggle bolts.
   c. For wood stud partitions, use hanger or lag bolts set into wood backing between studs. Coordinate with carpentry work to locate backing members.
   d. For steel-framed gypsum board assemblies, use hanger or lag bolts set into wood backing between studs. Coordinate with stud installation to locate backing members.
   e. For steel-framed gypsum board assemblies, fasten brackets directly to steel framing or concealed reinforcements using self-tapping screws of size and type required to support structural loads.
4. Secure top capping bars to top framing channels with 1/4-inch- (6-mm-) diameter "U" bolts spaced not more than 28 inches (700 mm) o.c.
5. Provide line posts at locations indicated or, if not indicated, as follows:
   a. On each side of sliding door openings.
   b. For partitions that are 7 to 9 feet (2.1 to 2.7 m) high, spaced at 15 to 20 feet (4.6 to 6.1 m) o.c.
   c. For partitions that are 10 to 12 feet (3.0 to 3.7 m) high, located between every other panel.
   d. For partitions that are more than 12 feet (3.7 m) high, located between each panel.
6. Provide seismic supports and bracing as indicated or, if not indicated, as recommended by manufacturer and as required for stability, extending and fastening members to supporting structure.
7. Where standard-width wire mesh partition panels do not fill entire length of run, provide adjustable filler panels to fill openings.
8. Install doors complete with door hardware.
9. Install service windows complete with window hardware.
10. Weld or bolt sheet metal bases to wire mesh partitions and doors **OR** where indicated, **as directed**.
11. Bolt accessories to wire mesh partition framing.

B. Wire Mesh Ceilings Erection
1. Anchor wall support angle to walls at 12 inches (305 mm) o.c. and as follows:
   a. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.

b. For hollow masonry anchorage, use toggle bolts.
c. For wood stud partitions, use hanger or lag bolts set into wood backing between studs. Coordinate with carpentry work to locate backing members.
d. For steel-framed gypsum board assemblies, use hanger or lag bolts set into wood backing between studs. Coordinate with stud installation to locate backing members.
e. For steel-framed gypsum board assemblies, fasten brackets directly to steel framing or concealed reinforcements using self-tapping screws of size and type required to support structural loads.

2. Attach wire mesh ceiling panels to wall support angles with bolts at 12 inches (305 mm) o.c.
3. Attach wire mesh ceiling panels to wire mesh partitions with slotted angles bolted to sides of ceiling panels and to top of partitions at 12 inches (305 mm) o.c.
4. Attach wire mesh ceiling panels to intermediate supports as recommended by manufacturer.
5. Provide seismic supports and bracing as indicated or, if not indicated, as recommended by manufacturer and as required for stability, extending and fastening members to supporting structure.

C. Wire Mesh Storage Lockers Erection

1. Anchor wire mesh storage lockers to floor with 3/8-inch- (9.5-mm-) diameter, expansion anchors at 12 inches (305 mm) o.c. through bottom panel framing. Shim panel framing as required to achieve level and plumb installation.
2. Anchor wire mesh storage lockers to walls at 12 inches (305 mm) o.c. through back corner panel framing and as follows:
   a. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.
   b. For hollow masonry anchorage, use toggle bolts.
   c. For wood stud partitions, use hanger or lag bolts set into wood backing between studs. Coordinate with carpentry work to locate backing members.
   d. For steel-framed gypsum board assemblies, use hanger or lag bolts set into wood backing between studs. Coordinate with stud installation to locate backing members.
   e. For steel-framed gypsum board assemblies, fasten brackets directly to steel framing or concealed reinforcements using self-tapping screws of size and type required to support structural loads.
3. Attach adjacent wire mesh storage lockers to each other through side panel framing.
4. Install horizontal dividers/shelving in double-tier storage lockers.
5. Install doors complete with door hardware.

D. Wire Mesh Stairway Partitions Erection

1. Anchor wire mesh stairway partitions to floor with 3/8-inch- (9.5-mm-) diameter, postinstalled expansion anchors at 12 inches (305 mm) o.c. through floor shoes located at each post. Adjust wire mesh partition posts in floor shoes to achieve level and plumb installation.
2. Anchor angle clips supporting wire mesh stairway partitions at stairs and intermediate landings with 3/8-inch- (9.5-mm-) diameter, postinstalled expansion anchors at 12 inches (305 mm) o.c. Weld stairway partition framing to angle clips.
3. Provide seismic supports and bracing as indicated or, if not indicated, as recommended by manufacturer and as required for stability, extending and fastening members to supporting structure.
4. Install doors complete with door hardware.

E. Wire Mesh Equipment Barriers Erection

1. Anchor wire mesh equipment barriers to floor with 3/8-inch- (9.5-mm-) diameter, expansion anchors through post bases. Shim post bases as required to achieve level and plumb installation.
2. Floor anchors may be set with power-actuated fasteners instead of postinstalled expansion anchors if indicated on Shop Drawings.
3. Install gates complete with gate hardware.

F. Adjusting And Cleaning
1. Adjust doors **OR** gates **OR** service windows, **as directed**, to operate smoothly and easily, without binding or warping. Adjust hardware to function smoothly. Confirm that latches and locks engage accurately and securely without forcing or binding.
2. Remove and replace defective work including doors and framing that are warped, bowed, or otherwise unacceptable.
3. Touchup Painting: Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with the same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
4. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 10605

SECTION 10650 - OPERABLE PANEL PARTITIONS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for operable panel partitions. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Manually operated, acoustical panel partitions.
b. Electrically operated, acoustical panel partitions.
c. Manually operated, fire-rated panel partitions.
d. Manually operated, glass panel partitions.

C. Definitions
1. ADA-ABA Accessibility Guidelines: U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA) and Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities."
2. Glass and Glazing Definitions: See Division 08 Section "Glazing".
3. NIC: Noise Isolation Class.
4. NRC: Noise Reduction Coefficient.
5. STC: Sound Transmission Class.

D. Performance Requirements
1. Delegated Design: Design operable panel partitions, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Operable panel partitions shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the panels will remain in place without separation of any parts from the system when subjected to the seismic forces specified."
3. Acoustical Performance: Provide operable panel partitions tested by a qualified testing agency for the following acoustical properties according to test methods indicated:
a. Sound-Transmission Requirements: Operable panel partition assembly tested for laboratory sound-transmission loss performance according to ASTM E 90, determined by ASTM E 413, and rated for not less than the STC indicated.
b. Noise-Reduction Requirements: Operable panel partition assembly, identical to partition tested for STC, tested for sound-absorption performance according to ASTM C 423, and rated for not less than the NRC indicated.
c. Acoustical Performance Requirements: Installed operable panel partition assembly, identical to partition tested for STC, tested for NIC according to ASTM E 336, determined by ASTM E 413, and rated for 10 dB less than STC value indicated.
4. Fire Resistance: Provide fire-rated operable panel partition assemblies including pass doors with fire-resistance ratings indicated.
a. Pass Doors: Provide doors in fire-rated operable panel partition assemblies with fire-resistance ratings indicated. Pass doors shall meet positive-pressure requirements.

E. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:

a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that operable panel partitions comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
b. Product Data for Credit EQ 4.4: For each composite wood product used in operable panel partitions, documentation indicating that product contains no urea formaldehyde.

3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. For installed products indicated to comply with design loads, include structural analysis data for attachments, signed and sealed by the qualified professional engineer responsible for their preparation.
   b. Indicate storage and operating clearances. Indicate location and installation requirements for hardware and track, blocking, and direction of travel.
   c. Wiring Diagrams: For power, signal, and control wiring.
4. Samples: For each type of exposed material, finish, covering, or facing indicated.
5. Delegated-Design Submittal: For operable panel partitions indicated to comply with performance requirements, including analysis data and calculations signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Design Calculations: Calculate requirements for seismic restraints.
6. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, based on input from installers of the items involved:
7. Setting Drawings: For embedded items and cutouts required in other work, including support-beam, mounting-hole template.
8. Seismic Qualification Certificates: For operable panel partitions, accessories, and components, from manufacturer.
9. Product Certificates.
10. Product Test Reports.
11. Field quality-control reports.
12. Operation and Maintenance Data.
13. Warranty: Sample of special warranty.

F. Quality Assurance
1. Manufacturer Qualifications: A qualified manufacturer that is certified for chain of custody by an FSC-accredited certification body.
2. Installer Qualifications: An employer of workers trained and approved by manufacturer.
3. Forest Certification: Fabricate products with wood, wood veneers, and wood-based panel products produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
4. Fire-Test-Response Characteristics: Provide panels with finishes meeting one of the following as determined by testing identical products by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
   a. Surface-Burning Characteristics: As determined by testing per ASTM E 84.
      1) Flame-Spread Index: 25 or less **OR** 26 to 75 **OR** 76 to 200, **as directed**.
      2) Smoke-Developed Index: 450 or less.
   b. Fire Growth Contribution: Meeting acceptance criteria of local code and authorities having jurisdiction when tested according to NFPA 265 **OR** NFPA 286, **as directed**.
5. Fire-Rated Door Assemblies: Comply with NFPA 80, based on testing according to UL 10B.
   a. Oversize Fire-Rated Door Assemblies: For units exceeding sizes of tested assemblies, provide certification by a testing agency acceptable to authorities having jurisdiction that doors comply with standard construction requirements for tested and labeled fire-rated door assemblies except for size.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling

1. Protectively package and sequence panels in order for installation. Clearly mark packages and panels with numbering system used on Shop Drawings. Do not use permanent markings on panels.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of operable panel partitions that fail in materials or workmanship within two years from date of Substantial Completion.

1.2 PRODUCTS

A. Materials
1. Steel Frame: Steel sheet, manufacturer's standard **OR** 0.0508-inch (1.3-mm) **OR** 0.0641-inch (1.6-mm) **OR** 0.0747-inch (1.9-mm), **as directed**, nominal minimum thickness for uncoated steel.
2. Steel Face/Liner Sheets: Tension-leveled steel sheet, manufacturer's standard **OR** minimum 0.0299-inch (0.75-mm) **OR** 0.0359-inch (0.9-mm) **OR** 0.0478-inch (1.2-mm) **OR** 0.0598-inch (1.5-mm) **OR** 0.0747-inch (1.9-mm), **as directed**, nominal minimum thickness for uncoated steel.
3. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use, corrosion resistance, and finish indicated; ASTM B 221 (ASTM B 221M) for extrusions; manufacturer's standard strengths and thicknesses for type of use.
   a. Frame Reinforcement: Manufacturer's standard steel or aluminum.
4. Wood Frame: Clear, vertical-grain, straight, kiln-dried, wood **OR** fire-retardant-treated wood, **as directed**; of manufacturer's standard species **OR** one of the following species, **as directed**:
   a. Cherry.
   b. Hemlock.
   c. Maple.
   d. Meranti.
   e. Poplar.
   f. Red oak.
5. Gypsum Board: ASTM C 36/C 36M.
6. Cement Board: ASTM C 1288.
7. Plywood: DOC PS 1.
8. Particleboard: ANSI A208.1, made with binder containing no urea formaldehyde.
9. Medium-Density Fiberboard: ANSI A208.2, made with binder containing no urea formaldehyde.

B. Operable Acoustical Panels
1. Operable Acoustical Panels: Operable acoustical panel partition system, including panels, seals, finish facing, suspension system, operators, and accessories.
2. Panel Operation: Manually operated, individual **OR** Manually operated, paired **OR** Manually operated, continuously hinged **OR** Electrically operated, continuously hinged, **as directed**, panels.
3. Panel Construction: Provide top reinforcement as required to support panel from suspension components and provide reinforcement for hardware attachment. Fabricate panels with tight hairline joints and concealed fasteners. Fabricate panels so finished in-place partition is rigid; level; plumb; aligned, with tight joints and uniform appearance; and free of bow, warp, twist, deformation, and surface and finish irregularities.
4. Dimensions: Fabricate operable acoustical panel partitions to form an assembled system of dimensions indicated and verified by field measurements.
   a. Panel Width: Standard widths **OR** Equal widths **OR** As indicated, **as directed**.
5. STC: Not less than 38 **OR** 41 **OR** 45 **OR** 47 **OR** 50 **OR** 52 **OR** 54, **as directed**.
6. NRC: Not less than 0.50 **OR** 0.60 **OR** 0.65 **OR** 0.90, **as directed**.
7. Panel Weight: 8 lb/sq. ft. (40 kg/sq. m) **OR** 10 lb/sq. ft. (50 kg/sq. m) **OR** 12 lb/sq. ft. (59 kg/sq. m), **as directed**, maximum.
8. Panel Thickness: Not less than 3 inches (75 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm), **as directed**.

9. Panel Closure: Manufacturer's standard.
   a. Initial Closure: Flexible, resilient PVC, bulb-shaped acoustical seal **OR** Fixed jamb **OR** As indicated, **as directed**.
   b. Final Closure: Constant-force, lever-operated mechanical closure expanding from panel edge to create a constant-pressure acoustical seal **OR** Hinged jamb closure **OR** Hinged communicating panel **OR** Fixed jamb **OR** Angle jamb **OR** Flexible, resilient PVC, bulb-shaped acoustical seal, **as directed**.
10. Hardware: Manufacturer's standard as required to operate operable panel partition and accessories; with decorative, protective finish.
   a. Hinges: Manufacturer's standard **OR** Concealed (invisible), **as directed**.
   b. Exit Device: Manufacturer's standard.

C. Operable Fire-Rated Panels
1. Operable Fire-Rated Panels: Operable fire-rated acoustical panel partition system, including panels, seals, finish facing, suspension system, operators, and accessories.
2. Panel Operation: Manually operated, individual **OR** Manually operated, paired, **as directed**, panels.
3. Panel Construction: Provide top reinforcement as required to support panel from suspension components and provide reinforcement for hardware attachment. Fabricate panels with tight hairline joints and concealed fasteners. Fabricate panels so finished in-place partition is rigid; level; plumb; aligned, with tight joints and uniform appearance; and free of bow, warp, twist, deformation, and surface and finish irregularities.
4. Dimensions: Fabricate operable fire-rated panel partitions to form an assembled system of dimensions indicated and verified by field measurements.
   a. Panel Width: Standard widths **OR** Equal widths **OR** As indicated, **as directed**.
5. Fire Rating: 1 hour **OR** 2 hours, **as directed**.
6. STC: Not less than 38 **OR** 41 **OR** 45 **OR** 47 **OR** 50 **OR** 52 **OR** 54, **as directed**.
7. NRC: Not less than 0.50 **OR** 0.60 **OR** 0.65 **OR** 0.90, **as directed**.
8. Panel Weight: 8 lb/sq. ft. (40 kg/sq. m) **OR** 10 lb/sq. ft. (50 kg/sq. m) **OR** 12 lb/sq. ft. (59 kg/sq. m), **as directed**, maximum.
9. Panel Thickness: Not less than 3 inches (75 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (102 mm), **as directed**.
10. Panel Closure: Manufacturer's standard fire-rated closure.
   a. Initial Closure: Flexible, resilient PVC, bulb-shaped acoustical seal **OR** Fixed jamb **OR** As indicated, **as directed**.
   b. Final Closure: Fire-rated, constant-force, lever-operated mechanical closure expanding from panel edge to create a constant-pressure acoustical seal **OR** hinged jamb closure **OR** hinged communicating panel **OR** fixed jamb **OR** angle jamb **OR** flexible, resilient PVC, bulb-shaped acoustical seal, **as directed**.
11. Hardware: Manufacturer's standard as required to operate fire-rated operable panel partition and accessories; with decorative, protective finish.
   a. Hinges: Manufacturer's standard **OR** Concealed (invisible), **as directed**.
   b. Exit Device: Manufacturer's standard.

D. Operable Glass Panels
1. Operable Glass Panels: Operable frameless aluminum **OR** aluminum-framed **OR** wood-framed, **as directed**, glass panel partition system with acoustical properties, **as directed**, including panels, seals, **as directed**, suspension system, operators, and accessories.
2. Panel Operation: Manually operated, individual **OR** Manually operated, paired **OR** Manually operated, continuously hinged, **as directed**, panels.
3. Panel Construction: Manufacturer's standard glazed panels, reinforced as required to support panel from suspension components and with reinforcement for hardware attachment. Fabricate panels with tight hairline joints and concealed fasteners. Fabricate panels so finished in-place partition is rigid; level; plumb; aligned, with tight joints and uniform appearance; and free of bow, warp, twist, deformation, and surface and finish irregularities.

a. Factory-Glazed Fabrication: Glaze operable glass panels in the factory where practical and possible for applications indicated. Comply with manufacturer's written requirements and with requirements in Division 08 Section "Glazing".

4. Glass and Glazing:
   a. Safety Glass: Provide glass products complying with testing requirements in 16 CFR 1201, for Category II materials, unless those of Category I are expressly indicated and permitted.
   b. Glass: Manufacturer's standard **OR** Custom, **as directed**, glass and glass assemblies as indicated and complying with the following:
      1) Tempered Glass: ASTM C 1048, Kind FT (fully tempered), Type I (transparent flat glass), Class 1 (clear) **OR** Class 2 (tinted), **as directed**, Quality-Q3.
      2) Tempered Patterned Glass: ASTM C 1048, Kind FT (fully tempered), Type II (patterned flat glass), Class 1 (clear), Form 3 (patterned); and of quality, finish, and pattern specified.
      3) Laminated Glass: ASTM C 1172, with clear **OR** colored **OR** patterned **OR** graphic, **as directed**, interlayer.
         a) Annealed Float Glass: ASTM C 1036, Type I (transparent flat glass), Class 1 (clear) **OR** Class 2 (tinted), **as directed**, Quality-Q3.
         b) Patterned Glass: ASTM C 1036, Type II (patterned and wired flat glass), Class 1 (clear), Form 3 (patterned); and of quality, finish, and pattern specified.
      4) Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass as indicated, separated by a dehydrated interspace, and complying with ASTM E 774 for Class CBA units.
         a) Spacer Specifications: Manufacturer's standard spacer material and construction.
         b) Spacer Specifications: Manufacturer's standard spacer construction and material as follows: Aluminum with mill or clear anodic finish **OR** Aluminum with black, color anodic finish **OR** Aluminum with bronze, color anodic finish **OR** Aluminum with powdered-metal paint finish in color selected **OR** Galvanized steel **OR** Stainless steel, **as directed**.
      5) Glass Thickness: Manufacturer's standard thickness for indicated requirements **OR** As indicated **OR** 1/4 inch (6 mm) **OR** 3/8 inch (10 mm) **OR** 1 inch (25 mm) **OR** 2-1/4 inches (57 mm), **as directed**.
      6) Glass Vertical Edge: Polished **OR** Manufacturer's standard, permanently adhered edge trim, **as directed**.
   c. Glazing System: Manufacturer's standard factory-glazing system **OR** Manufacturer's standard factory-glazing system that produces acoustical seal **OR** Manufacturer's standard factory-glazing system as indicated, **as directed**.
5. Dimensions: Fabricate operable glass panel partitions to form an assembled system of dimensions indicated and verified by field measurements.
   a. Panel Width: Standard widths **OR** Equal widths **OR** As indicated, **as directed**.
6. STC: Not less than 36 **OR** 41 **OR** 46 **OR** 48, **as directed**.
7. Panel Weight: 8 lb/sq. ft. (40 kg/sq. m) **OR** 20 lb/sq. ft. (98 kg/sq. m), **as directed**, maximum.
8. Panel Frame Thickness: Maximum 1-7/8 inches (48 mm) **OR** 2-1/4 inches (57 mm) **OR** 3-3/4 inches (96 mm), **as directed**.
9. Panel Closure: Manufacturer's standard.
10. Hardware: Manufacturer's standard as required to operate operable panel partition and accessories; with decorative, protective finish.
11. Finishes:
    a. Exposed Metal: Match sample **OR** As selected from manufacturer's full range, **as directed**, as follows:
       1) Aluminum: Clear anodized **OR** Light bronze anodized **OR** Medium bronze anodized **OR** Dark bronze anodized **OR** Black anodized **OR** Baked powder coating, **as directed**.

2) Metal-Clad Aluminum: Satin stainless steel **OR** Polished stainless steel **OR** Satin brass **OR** Polished brass **OR** Satin bronze **OR** Polished bronze, **as directed**.

b. Wood Finish: Match sample **OR** As selected from manufacturer's full range, **as directed**, as follows:

1) Type: Transparent finish **OR** Transparent finish over stain, **as directed**, over wood variety indicated.

E. Seals

1. General: Provide types of seals indicated that produce operable panel partitions complying with acoustical and fire-resistive performance requirements, **as directed**, and the following:
   a. Manufacturer's standard seals.
   b. Seals made from materials and in profiles that minimize sound leakage.
   c. Seals fitting tight at contact surfaces and sealing continuously between adjacent panels and between operable panel partition perimeter and adjacent surfaces, when operable panel partition is extended and closed.
2. Vertical Seals: Deep-nesting, interlocking steel, **as directed**, astragals mounted on each edge of panel, with continuous PVC acoustical seal.
3. Horizontal Top Seals:
   a. Continuous-contact, extruded-PVC seal exerting uniform constant pressure on track.
      OR
      PVC-faced, mechanical, retractable, constant-force-contact seal exerting uniform constant pressure on track when extended.
      OR
      Continuous-contact, extruded-PVC seal exerting uniform constant pressure on track or PVC-faced, mechanical, retractable, constant-force-contact seal exerting uniform constant pressure on track when extended.
4. Horizontal Bottom Seals: PVC-faced, mechanical, retractable, constant-force-contact seal exerting uniform constant pressure on floor when extended, ensuring horizontal and vertical sealing and resisting panel movement.
   a. Mechanically Operated for Acoustical Panels: Extension and retraction of bottom seal by operating handle or built-in operating mechanism, with operating range not less than 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm), **as directed**, between retracted seal and floor finish.
      OR
      Mechanically Operated for Fire-Rated Panels: Extension and retraction of bottom seal by operating handle or built-in operating mechanism, with operating range not less than 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 4 inches (102 mm), **as directed**, between retracted seal and floor finish.
      OR
      Automatically Operated for Acoustical Panels: Extension and retraction of bottom seal automatically operated by movement of partition, with operating range not less than 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, between retracted seal and floor finish.

F. Finish Facing

1. General: Provide finish facings for panels that comply with indicated fire-test-response characteristics and that are factory applied to operable panel partitions with appropriate backing, using mildew-resistant nonstaining adhesive as recommended by facing manufacturer's written instructions.
   a. Apply facings **OR** one-piece, seamless facings, **as directed**, free of air bubbles, wrinkles, blisters, and other defects, with edges tightly butted, and **OR** with invisible seams complying with Shop Drawings for location, and, **as directed**, with no gaps or overlaps. Horizontal butted edges **OR** seams, **as directed**, are not permitted. Tightly secure and conceal raw and selvage edges of facing for finished appearance.

b. Where facings with directional or repeating patterns or directional weave **OR** directional, repeating, or matching grain, **as directed**, are indicated, mark facing top and attach facing in same direction.
c. Match facing pattern 72 inches (1830 mm) above finished floor.
d. Color/Pattern: Match samples **OR** As selected from manufacturer's full range, **as directed**.

2. Vinyl-Coated Fabric Wall Covering: Manufacturer's standard, mildew-resistant, washable, vinyl-coated fabric wall covering; complying with CFFA-W-101-D for type indicated; Class A.
   a. Antimicrobial Treatment: Additives capable of inhibiting growth of bacteria, fungi, and yeasts.
3. Carpet Wall Covering: Manufacturer's standard nonwoven, needle-punched carpet with fibers fused to backing, from same dye lot, treated to resist stains.
4. Fabric Wall Covering: Manufacturer's standard fabric **OR** 100 percent polyolefin woven fabric, **as directed**, from same dye lot, treated to resist stains.
5. High-Pressure Decorative Laminate: NEMA LD 3, Horizontal grade.
6. Wood Veneer: Laminated to noncombustible **OR** fire-retardant-treated wood, **as directed**, core with moisture-resistant adhesive, of wood species indicated.
   a. Wood Finish: Match sample **OR** As selected from manufacturer's full range, **as directed**, as follows:
      1) Type: Transparent finish **OR** Transparent finish over stain, **as directed**, over wood variety indicated.
7. Paint: Manufacturer's standard factory-painted finish.
   a. Color: As indicated **OR** As selected, **as directed**.
8. Cap-Trimmed Edges: Protective perimeter-edge trim with tight hairline joints concealing edges of panel and finish facing, finished as follows:
   a. Steel, Painted: Finished with manufacturer's standard neutral color **OR** Matching sample **OR** As selected from manufacturer's full range, **as directed**.
   b. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper required to comply with performance requirements; and with manufacturer's standard mill **OR** clear anodic **OR** color anodic, **as directed**, finish.
9. Trimless Edges: Fabricate exposed panel edges so finish facing wraps uninterrupted around panel, covering edge and resulting in an installed partition with facing visible on vertical panel edges, without trim, for minimal sightlines at panel-to-panel joints.

G. Suspension Systems
1. Suspension Tracks: Steel or aluminum mounted directly to overhead structural support, **OR** with adjustable steel hanger rods for overhead support, **as directed**, designed for type of operation, size, and weight of operable panel partition indicated. Size track to support partition operation and storage without damage to suspension system, operable panel partitions, or adjacent construction. Limit track deflection to no more than 0.10 inch (2.54 mm) between bracket supports. Provide a continuous system of track sections and accessories to accommodate configuration and layout indicated for partition operation and storage.
   a. Panel Guide: Aluminum; finished with factory-applied, decorative, protective finish.
   b. Head Closure Trim: As required for acoustical performance; with factory-applied, decorative, protective finish **OR** primed for field finish, **as directed**.
2. Carriers: Trolley system as required for configuration type, size, and weight of partition and for easy operation; with ball-bearing wheels.
   a. Multidirectional Carriers: Capable of negotiating 90-degree L, T, and X intersections without track switches.
3. Track Intersections, Switches, and Accessories: As required for type of operation, storage, track configuration, and layout indicated for operable panel partitions, and compatible with partition assembly specified. Fabricate track intersections and switches from steel or aluminum.
   a. Curve-and-Diverter Switches: Allowing radius turns to divert panels to an auxiliary track.
   b. L Intersections: Allowing panels to change 90 degrees in direction of travel.
   c. T Intersections: Allowing panels to pass through or change 90 degrees to another direction of travel.

d. X Intersections: Allowing panels to pass through or change travel direction full circle in 90-degree increments, and allowing 1 partition to cross track of another.
e. Multidirectional Switches: Adjustable switch configuring track into L, T, or X intersections and allowing panels to be moved in all pass-through, 90-degree change, and cross-over travel direction combinations.
f. Center carrier stop.

4. Aluminum Finish: Mill finish or manufacturer's standard, factory-applied, decorative finish unless otherwise indicated.
5. Steel Finish: Manufacturer's standard, factory-applied, corrosion-resistant, protective coating unless otherwise indicated.

H. Electric Operators

1. General: Provide factory-assembled electric operation system of size and capacity recommended and provided by operable panel partition manufacturer for partition specified; with electric motor and factory-prewired motor controls, speed reducer, chain drive, remote-control stations, control devices, and accessories required for proper operation. Include wiring from motor control to motor. Coordinate operator wiring requirements and electrical characteristics with building electrical system.
2. Comply with NFPA 70.
3. Control Equipment: Complying with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6.
4. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
   a. Voltage: 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.
   b. Horsepower: 1/4 **OR** 1/3 **OR** 3/4 **OR** Manufacturer's standard, **as directed**.
   c. Efficiency: Standard **OR** Premium, **as directed**.
   d. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
   e. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
   f. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
   g. Phase: Single **OR** Polyphase, **as directed**.
5. Remote-Control Stations: Two single-key-operated, constant-pressure control stations located remotely from each other on opposite sides and opposite ends of partition run. Wire in series to require simultaneous activation of both key stations to operate partition. Each three-position control station labeled "Open," "Close," and "Off **OR** Stop, **as directed**." Provide two keys per station.
6. Obstruction-Detection Devices: Provide each motorized operable panel partition with automatic safety sensor indicated, that causes operator to immediately shut off motor **OR** stop and reverse direction, **as directed**.
   a. Sensor Edge: Contact-pressure-sensitive safety edge along partition's leading edge.
   b. Sensor Mat: Electrically operated, contact-weight-sensitive safety mat in storage pocket area.
   c. Infrared Sensor System: Designed to detect an obstruction in partition's path and sound an audible alarm, without obstruction contacting partition.
7. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop operable panel partition at fully extended and fully stacked positions.
8. Emergency Release Mechanism: Quick disconnect-release of electric-motor drive system, permitting manual operation in event of operating failure.

I. Accessories

1. Pass Doors: Fabricated to comply with recommendations in ICC/ANSI A117.1 **OR** the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines, **as directed**. Swinging door built into and matching panel materials, **OR** construction, **OR**

acoustical qualities, **OR** fire rating, **as directed**, finish, and thickness, complete with frames and operating hardware. Hinges finished to match other exposed hardware.

a. Single Pass Door: 36 by 80 inches (914 by 2032 mm) **OR** 36 by 84 inches (914 by 2134 mm), **as directed**, with the following:

b. Double Pass Door: 72 by 80 inches (1829 by 2032 mm) **OR** 72 by 84 inches (1829 by 2134 mm), **as directed**, with the following:

1) Door Seals: Mechanically operated floor seal on panels containing pass doors **OR** Sweep floor seals, **as directed**.

2) Panic **OR** Fire, **as directed**, exit device.

3) Concealed door closer.

4) Door Viewer: Installed with view in direction of swing.

5) Exit Sign: Recessed, self-illuminated.

6) Latchset: Passage set.

7) Lock: Key-operated lock cylinder, keyed to master key system, **as directed**, operable from both sides of door. Include two keys per lock.

OR

Lock: Deadlock to receive cylinder, operable from both sides of door. Refer to Division 06 for lock cylinder and keying requirements.

2. Storage Pocket Door: Full height at end of partition runs to conceal stacked partition; of same materials, finish, construction, thickness, and acoustical qualities as panels; complete with operating hardware and acoustical seals at soffit, floor, and jambs, **as directed**. Hinges in finish to match other exposed hardware.

a. Manufacturer's standard method to secure storage pocket door in closed position.

OR

Rim Lock: Key-operated lock cylinder, keyed to master key system, **as directed**, to secure storage pocket door in closed position. Include two keys per lock.

OR

Rim Lock: Deadlock to receive cylinder, to secure storage pocket door in closed position. Refer to Division 06 for lock cylinder and keying requirements.

3. Electric Interlock: Provide each motorized operable panel partition with electric interlocks at locations indicated, to prevent operation of operable panel partition under the following conditions:

a. On storage pocket door, to prevent operation if door is not in fully open position.

b. On partitions at location of convergence by another partition, to prevent operation if merging partitions are in place.

4. Windows: Manufacturer's standard **OR** As indicated, **as directed**.

5. Work Surfaces: Quantities, placement, and size indicated.

a. Surface: Porcelain steel marker/projection surface **OR** Self-healing, tackable, vinyl-coated fabric wall covering, complying with CFFA-W-101-D, Type II, and indicated fire-test-response characteristics; laminated to natural cork tackboard, **as directed**.

b. Surface Color: Matching sample **OR** As selected from manufacturer's full range, **as directed**.

c. Size: Full width and height of panel **OR** Full width of panel by 48 inches (1219 mm) **OR** 48 by 48 inches (1219 by 1219 mm) **OR** As indicated on Drawings, **as directed**.

d. Trim: Aluminum slip-on or snap-on trim with no visible screws or exposed joints and with corners mitered to a neat, hairline joint.

6. Chalk Tray and Eraser Pocket, **as directed**: Manufacturer's standard.

a. Aluminum with mill **OR** clear anodic **OR** color anodic, **as directed**, finish.

7. Chair Rails: Recessed **OR** Surface mounted, **as directed**, in locations indicated on Drawings.

8. Vertical Edge Trim: Manufacturer's standard transparent **OR** thin aluminum astragal, **as directed**, trim to protect vertical edges of glass in frameless panels.

1.3 EXECUTION

A. Installation

1. General: Comply with ASTM E 557 except as otherwise required by operable panel partition manufacturer's written installation instructions.
2. Install operable panel partitions and accessories after other finishing operations, including painting, have been completed.
3. Install panels from marked packages in numbered sequence indicated on Shop Drawings.
4. Broken, cracked, chipped, deformed, or unmatched panels are not acceptable.
5. Broken, cracked, deformed, or unmatched gasketing or gasketing with gaps at butted ends is not acceptable.

B. Adjusting
1. Adjust operable panel partitions to operate smoothly, without warping or binding. Lubricate hardware, electric operator, **as directed**, and other moving parts.
2. Adjust pass doors and storage pocket doors, **as directed**, to operate smoothly and easily, without binding or warping. Check and readjust operating hardware. Confirm that latches and locks engage accurately and securely without forcing or binding.

C. Field Quality Control
1. This paragraph is applicable if sound control is critical. Installer shall conduct a light-leakage test at completion of installation, and prior to NIC testing, to correct alignment of vertical joints and top and bottom seals.
2. Light-Leakage Test: Illuminate one side of partition installation and observe vertical joints and top and bottom seals for voids; adjust partitions for acceptable fit.
3. NIC Testing: Engage a qualified testing agency to perform tests and inspections.
4. Testing Methodology: Perform testing of installed operable panel partition for noise isolation according to ASTM E 336, determined by ASTM E 413, and rated for not less than NIC indicated. Adjust and fit partitions to comply with NIC test method requirements.
5. Testing Extent: Testing agency shall randomly select one operable panel partition installation(s) for testing.
6. Repair or replace operable panel partitions that do not comply with requirements.
7. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of repaired, replaced, or additional work with specified requirements.
8. Prepare test and inspection reports.

D. Cleaning
1. Clean soiled surfaces of operable panel partitions to remove dust, loose fibers, fingerprints, adhesives, and other foreign materials according to manufacturer's written instructions.

END OF SECTION 10650

Task	Specification	Specification Description
10672	06110a	Miscellaneous Carpentry

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SECTION 10710 - EXTERIOR SHUTTERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for exterior shutters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data:
a. Manufacturer's data.
b. For wood-preservative-treated materials and finishes indicated.
2. Shop Drawings: Show location of each item, dimensioned plans and elevations, large-scale details, attachment devices, and other components.
3. Samples: For lumber for exterior wood stain finish and lumber and panel products for shop-applied opaque finish, for each finish system and color, with one-half of exposed surface finished.
4. LEED Submittals:
a. Credit MR 7: Certificates of chain-of-custody signed by manufacturers certifying that products specified to be made from certified wood were made from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC 1.2, "Principles and Criteria."
5. Woodwork Quality Standard Compliance Certificates: AWI Quality Certification Program certificates **OR** WIC-certified compliance certificates, **as directed**.

C. Quality Assurance
1. Quality Standard: Unless otherwise indicated, comply with AWI's "Architectural Woodwork Quality Standards" **OR** WIC's "Manual of Millwork," **as directed.**
2. Forest Certification: Provide exterior architectural woodwork produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC 1.2, "Principles and Criteria."

D. Delivery, Storage, and Handling
1. Do not deliver shutters until painting and similar operations that could damage shutters have been completed in installation areas.

1.2 PRODUCTS

A. Wood Shutters
1. Materials
a. Preservative Treatment by Nonpressure Process: Comply with AWPA N1 using the following preservative for woodwork items indicated to receive water-repellent preservative treatment:
1) Water-Repellent Preservative: Formulation containing 3-iodo-2-propynyl butyl carbamate (IPBC) complying with AWPA P8 as its active ingredient.
2) Water-Repellent Preservative/Insecticide: Formulation containing 3-iodo-2-propynyl butyl carbamate (IPBC) as its active ingredient, combined with an insecticide containing chlorpyrifos as its active ingredient, both complying with AWPA P8.
2. Fabrication
a. Wood Moisture Content: 9 to 15 **OR** 10 to 15 **OR** 7 to 12, **as directed,** percent.
b. Complete fabrication, including assembly, finishing, and hardware application, to maximum extent possible, before shipment to Project site. Disassemble components only as

necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

c. Woodwork for Transparent Finish:
   1) Grade: Premium **OR** Custom **OR** Economy, **as directed**.
   2) Wood Species: Teak **OR** African mahogany **OR** White oak **OR** All-heart redwood **OR** Western red cedar **OR** Eastern white pine, **as directed**.

d. Woodwork for Opaque Finish:
   1) Grade: Premium **OR** Custom **OR** Economy, **as directed**.
   2) Wood Species: All-heart redwood **OR** Western red cedar **OR** Ponderosa pine **OR** Eastern white pine, sugar pine, or western white pine **OR** Spanish Cedar, **OR** Cyprus, **OR** Cedar, **OR** Any closed-grain hardwood, **as directed**.

e. Backout or groove backs of flat trim members and kerf backs of other wide, flat members, except for members with ends exposed in finished work.

f. Shop Priming: Shop prime woodwork for paint finish with one coat of wood primer specified in Division 07.
   1) Backpriming: Apply one coat of sealer or primer, compatible with finish coats, to concealed surfaces of woodwork. Apply two coats to surfaces installed in contact with concrete or masonry and to end-grain surfaces.

B. Thermo-Plastic Shutters
   1. Provide high impact resistant, minimum 1-inch thick, pressure molded plastic shutters, shop assembled.
      a. Color shall be throughout material, with acrylic top layer to provide fade and UV protection. Color as directed. Provide lifetime warranty against fading.

C. Duckboard Composite Panels

D. Installation Materials
   1. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide nonferrous-metal or hot-dip galvanized anchors and inserts as required for corrosion resistance. Provide toothed-steel or lead expansion sleeves for drilled-in-place anchors.

E. Fabrication, General
   1. Fabricate shutters to dimensions, profiles, and details indicated.
   2. Complete fabrication, including assembly, and hardware application, to maximum extent possible, before shipment to Project site.

F. Size
   1. Sizes shall be as directed.

G. Configuration: As directed.
   1. Louvered decorative shutters.
   2. Raised panel decorative shutters.
   3. Board-and-Batten shutters.

1.3 EXECUTION

A. Preparation
   1. Before installing shutters, examine for completion, including removal of packing and backpriming.

B. Installation
   1. Before installation, condition wood shutters to average prevailing humidity conditions in installation areas. Before installing shutters, examine shop-fabricated work for completion and complete work as required.

2. Preservative-Treated Wood: Where cut or drilled in field, treat cut ends and drilled holes according to AWPA M4.
3. Install shutters in accordance with manufacturer's instructions.
4. Install shutters level, plumb, true, and straight.
5. Anchor shutters to anchors or blocking built in or directly attached to substrates.
6. Fill nail and screw holes with matching filler where exposed.
7. Refer to Division 07 for final finishing of installed shutters.

END OF SECTION 10710

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Task	Specification	Specification Description
10710	01352	No Specification Required

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SECTION 10810 - TOILET AND BATH ACCESSORIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for toilet and bath accessories. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Public-use washroom accessories.
b. Public-use shower room accessories.
c. Private-use bathroom accessories.
d. Healthcare accessories.
e. Warm-air dryers.
f. Childcare accessories.
g. Underlavatory guards.
h. Custodial accessories.

C. Submittals
1. Product Data: For each type of product indicated.
2. Product Schedule:
a. Identify locations using room designations indicated on Drawings.
b. Identify products using designations indicated on Drawings.

D. Warranty
1. Special Mirror Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrors that develop visible silver spoilage defects and that fail in materials or workmanship within 15 years from date of Substantial Completion.

1.2 PRODUCTS

A. Materials
1. Stainless Steel: ASTM A 666, Type 304, 0.0312-inch (0.8-mm) minimum nominal thickness, unless otherwise indicated.
2. Brass: ASTM B 19 flat products; ASTM B 16 (ASTM B 16M), rods, shapes, forgings, and flat products with finished edges; or ASTM B 30, castings.
3. Steel Sheet: ASTM A 1008/A 1008M, Designation CS (cold rolled, commercial steel), 0.0359-inch (0.9-mm) minimum nominal thickness.
4. Galvanized Steel Sheet: ASTM A 653/A 653M, with G60 (Z180) hot-dip zinc coating.
5. Galvanized Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.
6. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.
7. Chrome Plating: ASTM B 456, Service Condition Number SC 2 (moderate service).
8. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.
9. ABS Plastic: Acrylonitrile-butadiene-styrene resin formulation.

B. Public-Use Washroom Accessories
1. Toilet Tissue (Roll) Dispenser:

a. Description: Roll-in-reserve dispenser with hinged front secured with tumbler lockset **OR** Single-roll dispenser **OR** Double-roll dispenser **OR** Double-roll dispenser with shelf, **as directed**.
b. Mounting: Recessed **OR** Partition mounted serving two adjacent toilet compartments **OR** Surface mounted, **as directed**.
c. Operation: Noncontrol delivery with standard spindle **OR** Noncontrol delivery with theft-resistant spindle **OR** Spindleless with tension-spring controlled delivery **OR** Spindleless with tension-spring controlled delivery and self-locking device extending through core that prevents core removal until roll is empty **OR** Eccentric-shaped, molded-plastic spindle revolves one-half revolution per dispensing operation for controlled delivery; core cannot be removed until roll is empty, **as directed**.
d. Capacity: Designed for 4-1/2- or 5-inch- (114- or 127-mm-) **OR** 5-inch- (127-mm-), **as directed,** diameter tissue rolls.
e. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** Chrome-plated zinc alloy (zamac) or steel **OR** Satin-finish aluminum bracket with plastic spindle **OR** ABS plastic, gray, **as directed**.

2. Combination Toilet Tissue Dispenser:
   a. Description: Combination unit with double-roll toilet tissue dispenser and the following:
      1) Removable sanitary-napkin waste receptacle with self-closing disposal-opening cover.
      2) Seat-cover dispenser with minimum capacity of 500 **OR** 1000, **as directed,** single or half-fold seat covers.
   b. Mounting: Recessed **OR** Surface mounted **OR** Partition mounted, dual access with two tissue rolls per compartment **OR** Partition mounted, dual access with two tissue rolls per compartment and with one side that mounts flush with partition of accessible compartment, **as directed**.
   c. Toilet Tissue Dispenser Capacity: 4-1/2- or 5-inch- (114- or 127-mm-) diameter tissue rolls.
   d. Toilet Tissue Dispenser Operation: Noncontrol delivery with theft-resistant spindles.
   e. Material and Finish: Stainless steel, No. 4 finish (satin).
   f. Lockset: Tumbler type.
3. Toilet Tissue (Folded) Dispenser:
   a. Description: Folded-tissue dispenser with cover hinged at bottom.
   b. Mounting: Surface mounted.
   c. Minimum Capacity: 1250 single-fold tissues.
   d. Material and Finish: Stainless steel, No. 4 finish (satin).
   e. Lockset: Tumbler type.
   f. Refill Indicators: Pierced slots at front.
4. Toilet Tissue (Jumbo-Roll) Dispenser:
   a. Description: One-roll unit **OR** Two-roll unit with sliding panel to expose other roll, **as directed**.
   b. Mounting: Surface mounted.
   c. Capacity: 9- or 10-inch- (228- or 254-mm-) diameter rolls.
   d. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** ABS plastic, gray, **as directed**.
   e. Lockset: Tumbler type.
   f. Refill Indicator: Pierced slots at front.
5. Paper Towel (Folded) Dispenser:
   a. Mounting: Recessed **OR** Semirecessed **OR** Deck mounted, recessed **OR** Surface mounted, **as directed**.
   b. Minimum Capacity: 400 C-fold or 525 multifold towels **OR** 600 C-fold or 800 multifold towels **OR** 400 single-fold towels, **as directed**.
   c. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** ABS plastic, gray, **as directed**.
   d. Lockset: Tumbler type.
   e. Refill Indicators: Pierced slots at sides or front.
6. Paper Towel (Roll) Dispenser:

a. Description: Lever-actuated mechanism permits controlled delivery of paper rolls in preset lengths per stroke.
b. Mounting: Recessed **OR** Semirecessed **OR** Surface mounted, **as directed**.
c. Minimum Capacity: 8-inch (203-mm) wide, 800-foot (244-m) long roll.
d. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** ABS plastic, gray, **as directed**.
e. Lockset: Tumbler type.

7. Waste Receptacle:
   a. Mounting: Open top, recessed **OR** Self-closing disposal-opening cover, recessed **OR** Semirecessed **OR** Surface mounted **OR** Wall mounted for corner installation **OR** Freestanding **OR** Undercounter, **as directed**.
   b. Minimum Capacity: Capacity in gal. (L) **as directed**.
   c. Material and Finish: Stainless steel, No. 4 finish (satin).
   d. Liner: Reusable vinyl liner.
   e. Lockset: Tumbler type for waste-receptacle.
8. Combination Towel (Folded) Dispenser/Waste Receptacle:
   a. Description: Combination unit for dispensing C-fold or multifold towels, with removable waste receptacle.
   b. Mounting: Surface mounted **OR** Surface mounted with stainless-steel collar **OR** Recessed **OR** Recessed with projecting receptacle **OR** Semirecessed, **as directed**.
      1) Designed for nominal 4-inch (100-mm) **OR** 6-inch (150-mm), **as directed,** wall depth.
   c. Minimum Towel-Dispenser Capacity: 600 C-fold or 800 multifold paper towels.
   d. Minimum Waste-Receptacle Capacity: 4 gal. (15 L) **OR** 12 gal. (45.4 L), **as directed.**
   e. Material and Finish: Stainless steel, No. 4 finish (satin).
   f. Liner: Reusable, vinyl waste-receptacle liner.
   g. Lockset: Tumbler type for towel-dispenser compartment and waste receptacle.
9. Combination Towel (Roll) Dispenser/Waste Receptacle:
   a. Description: Combination unit for dispensing preset length of roll paper towels, with removable waste receptacle.
   b. Mounting: Recessed **OR** Semirecessed **OR** Surface mounted, **as directed**.
   c. Minimum Towel-Dispenser Capacity: 8-inch (203-mm) wide, 800-foot (244-m) long roll.
   d. Minimum Waste Receptacle Capacity: 8 gal. (30 L) **OR** 12 gal. (45.4 L) **OR** 15 gal. (56.8 L), **as directed**.
   e. Material and Finish: Stainless steel, No. 4 finish (satin).
   f. Liner: Reusable, vinyl waste-receptacle liner.
   g. Lockset: Tumbler type for towel dispenser compartment and waste receptacle.
10. Multipurpose Soap/Towel Dispenser Unit:
    a. Description: Combination unit for dispensing soap in liquid or lotion **OR** lather, **as directed,** form and folded towels.
    b. Mounting: Recessed, designed for nominal 4-inch (100-mm) wall depth **OR** Surface mounted with stainless-steel collar, **as directed**.
    c. Minimum Soap-Dispenser Capacity: 80 oz. (2.36 L).
    d. Minimum Towel-Dispenser Capacity: 600 C-fold or 800 multifold **OR** 1000 single-fold, **as directed,** towels.
    e. Material and Finish: Stainless steel, No. 4 finish (satin) for unit body and soap valve.
    f. Lockset: Tumbler type.
11. Liquid-Soap Dispenser:
    a. Description: Designed for dispensing soap in liquid or lotion **OR** lather, **as directed,** form.
    b. Mounting: Deck mounted on vanity **OR** Deck mounted on lavatory **OR** Horizontally oriented, recessed **OR** Horizontally oriented, surface mounted **OR** Vertically oriented, surface mounted, **as directed**.
    c. Capacity: Capacity in **oz. (mL), as directed.**
    d. Materials: Valve and reservoir materials and finishes, **as directed**.
    e. Lockset: Tumbler type.
    f. Refill Indicator: Window type.
12. Grab Bar:

a. Mounting: Flanges with concealed **OR** exposed, **as directed,** fasteners.
b. Material: Stainless steel, 0.05 inch (1.3 mm) thick.
   1) Finish: Smooth, No. 4, satin finish **OR** Smooth, No. 4, satin finish on ends and slip-resistant texture in grip area, **as directed**.
c. Outside Diameter: 1-1/4 inches (32 mm) **OR** [1-1/2 inches (38 mm), **as directed**.
d. Configuration and Length: As indicated on Drawings **OR** Straight, 36 inches (914 mm) long, **as directed**.

13. Vendor:
    a. Type: Sanitary napkin **OR** Sanitary napkin and tampon **OR** Condom, **as directed**.
    b. Mounting: Fully recessed, designed for 4-inch (100-mm) wall depth, **OR** Semirecessed, **OR** Surface mounted, **as directed**.
    c. Capacity: **As directed**.
    d. Operation: No coin (free) **OR** Single coin (25 cents) **OR** Two coin (50 cents), **as directed**.
    e. Exposed Material and Finish: Stainless steel, No. 4 finish (satin).
    f. Lockset: Tumbler type with separate lock and key for coin box.
14. Sanitary-Napkin Disposal Unit:
    a. Mounting: Recessed **OR** Partition mounted, dual access **OR** Surface mounted, **as directed**.
    b. Door or Cover: Self-closing disposal-opening cover and hinged face panel with tumbler lockset.
    c. Receptacle: Removable.
    d. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** ABS plastic, gray, **as directed**.
15. Seat-Cover Dispenser:
    a. Mounting: Surface mounted **OR** Recessed **OR** Partition mounted, dual access, **as directed**.
    b. Minimum Capacity: 250 **OR** 500, **as directed,** seat covers.
    c. Exposed Material and Finish: Stainless steel, No. 4 finish (satin) **OR** ABS plastic, gray, **as directed**.
    d. Lockset: Tumbler type.
16. Fold-Down Purse Shelf:
    a. Description: Hinged unit with spring-loaded shelf that automatically returns to vertical position.
    b. Nominal Size: 15 inches (381 mm) long by 5-1/2 inches (140 mm) wide.
    c. Material and Finish: Chrome-plated cast-zinc alloy (zamac) with stippled finish on tray or stainless steel, No. 4 finish (satin) **OR** Chrome-plated cast-zinc alloy (zamac) with stippled finish on tray and bright chrome finish on edges **OR** Stainless steel, No. 4 finish (satin), **as directed**.
17. Mirror Unit:
    a. Frame: Stainless-steel angle, 0.05 inch (1.3 mm) thick **OR** Stainless-steel channel **OR** Stainless steel, fixed tilt **OR** Stainless steel, adjustable tilt, **as directed**.
       1) Corners: Manufacturer's standard **OR** Mitered and mechanically interlocked **OR** Welded and ground smooth, **as directed**.
    b. Integral Shelf: 5 inches (127 mm) deep.
    c. Hangers: Produce rigid, tamper- and theft-resistant installation, using method indicated below.
       1) One-piece, galvanized steel, wall-hanger device with spring-action locking mechanism to hold mirror unit in position with no exposed screws or bolts.
       2) Wall bracket of galvanized steel, equipped with concealed locking devices requiring a special tool to remove.
    d. Size: As indicated on Drawings **OR as directed**.
18. Facial Tissue Dispenser:
    a. Mounting: Wall mounted, recessed **OR** Surface mounted, **as directed**.
    b. Nominal Depth: 2-1/4 inches (57 mm) **OR** 4 inches (102 mm), **as directed**.
    c. Capacity: 150 double-ply tissues.
    d. Material and Finish:

1) Dispenser Face: Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
2) Cabinet: Steel with corrosion-resistant finish.

C. Public-Use Shower Room Accessories
1. Shower Curtain Rod:
   a. Description: 1-inch (25.4-mm) OD; fabricated from nominal 0.0375-inch- (0.95-mm-) thick stainless steel **OR** 1-1/4-inch (32-mm) OD; fabricated from nominal **0.05-inch- (1.3-mm-) thick stainless steel, as directed.**
   b. Mounting Flanges: Stainless-steel flanges designed for exposed fasteners.
   c. Finish: No. 4 (satin).
2. Shower Curtain:
   a. Size: Minimum 6 inches (152 mm) **OR** 12 inches (305 mm), **as directed,** wider than opening by 72 inches (1828 mm) high.
   b. Material: Vinyl, minimum 0.006-inch- (0.15-mm-) thick, opaque, matte, **OR** Duck, minimum 8 oz. (227 g), white, 100 percent cotton, **OR** Nylon-reinforced vinyl, minimum 10-oz. (284-g) or 0.008-inch- (0.2-mm-) thick vinyl, with integral antibacterial agent, **as directed**.
   c. Color: White **OR** Green **OR** As selected from manufacturer's full range, **as directed**.
   d. Grommets: Corrosion resistant at minimum 6 inches (152 mm) o.c. through top hem.
   e. Shower Curtain Hooks: Chrome-plated or stainless-steel, spring wire curtain hooks with snap fasteners, sized to accommodate specified curtain rod. Provide one hook per curtain grommet.
3. Folding Shower Seat:
   a. Configuration: L-shaped seat, designed for wheelchair access **OR** Rectangular seat **OR** Triangular, corner-type seat **OR** Stainless-steel seat designed to fold into recessed-mounted, stainless-steel wall box, **as directed**.
   b. Seat: Phenolic or polymeric composite of slat-type or one-piece construction in color as selected **OR** White vinyl padded seat **OR** Stainless steel, No. 4 finish (satin); 0.05-inch (1.3-mm) minimum nominal thickness; with single-piece, pan-type construction and edge seams welded and ground smooth, **as directed**.
   c. Mounting Mechanism: Stainless steel, No. 4 finish (satin).
   d. Dimensions: **As directed.**
4. Soap Dish:
   a. Description: With **OR** Without, **as directed,** washcloth bar.
   b. Mounting: Recessed **OR** Surface mounted, **as directed**.
   c. Material and Finish: Stainless steel, No. 4 finish (satin).

D. Private-Use Bathroom Accessories
1. Toilet Tissue Dispenser:
   a. Description: Single-roll dispenser **OR** Double-roll dispenser **OR** Single-roll dispenser with hood **OR** Double-roll dispenser with hood, **as directed**.
   b. Mounting: Recessed **OR** Surface mounted, **as directed**.
   c. Capacity: Designed for 4-1/2- or 5-inch- (114- or 127-mm-) diameter tissue rolls.
   d. Material and Finish: Solid brass, polished **OR** Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Polished chrome-plated zinc alloy (zamac) **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
2. Shower Curtain Rod:
   a. Outside Diameter: 1 inch (25.4 mm) **OR** 1-1/4 inch (32 mm), **as directed**.
   b. Mounting: Flanges with exposed **OR** concealed, **as directed,** fasteners.
   c. Rod Material and Finish: Solid brass, polished **OR** Polished chrome-plated brass **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
   d. Flange Material and Finish: Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Polished chrome-plated zinc alloy (zamac) **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
   e. Accessories: Integral chrome-plated brass glide hooks.
3. Soap Dish:

a. Description: **As directed**.
b. Mounting: Recessed **OR** Surface mounted, **as directed**.
c. Material and Finish: Solid brass, polished **OR** Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Polished chrome-plated zinc alloy (zamac) **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.

4. Medicine Cabinet:
   a. Mounting: Recessed, for nominal 4-inch (100-mm) wall depth **OR** Surface mounted, **as directed**.
   b. Size: 18 by 24 inches (460 by 610 mm).
   c. Door: Framed mirror door concealing storage cabinet equipped with continuous hinge and spring-buffered, rod-type stop and magnetic door catch.
   d. Shelves: Three, adjustable.
   e. Material and Finish:
      1) Cabinet: Stainless steel, No. 4 finish (satin) **OR** Steel with corrosion resistant finish, **as directed**.
      2) Mirror Frame: **As directed.**
      3) Door: **As directed.**
      4) Hinge: **As directed.**
      5) Shelves: **As directed.**
5. Facial Tissue Dispenser:
   a. Mounting: Wall mounted, recessed **OR** Surface mounted, **as directed**.
   b. Depth: 2-5/8 inches (67 mm) **OR** 4 inches (102 mm), **as directed**.
   c. Material and Finish:
      1) Dispenser Face: Polished chrome-plated brass **OR** Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated steel **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
      2) Cabinet: Steel with corrosion-resistant finish.
6. Robe Hook:
   a. Description: Double-prong **OR** Single-prong, **as directed,** unit.
   b. Material and Finish: Solid brass, polished **OR** Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Polished chrome-plated zinc alloy (zamac) **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
7. Toothbrush and Tumbler Holder:
   a. Description: **As directed**.
   b. Material and Finish: Solid brass, polished **OR** Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Polished chrome-plated zinc alloy (zamac) **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
8. Towel Bar:
   a. Description: 3/4-inch- (19-mm-) square tube with rectangular end brackets **OR** 3/4-inch- (19-mm-) round tube with circular end brackets, **as directed**.
   b. Mounting: Flanges with concealed **OR** exposed, **as directed,** fasteners.
   c. Length: 18 inches (457 mm), **OR** 24 inches (610 mm), **OR** 30 inches (762 mm), **as directed**.
   d. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished) **OR** Polished aluminum, **as directed**.
9. Towel Pin:
   a. Description: Projecting minimum of 3 inches (75 mm) **OR** 5 inches (127 mm), **as directed,** from wall surface.
   b. Material and Finish: Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.
10. Towel Ring:
    a. Description: Pin projecting approximately 2-1/2 inches (63 mm) from wall with square **OR** circular **OR** oval **OR** trapezoidal, **as directed,** ring.

b. Pin Material and Finish: Solid brass, polished **OR** Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated brass **OR** Polished chrome-plated zinc alloy (zamac) **OR** Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished), **as directed**.

c. Ring Material and Finish: Matching pin **OR** Clear plastic, **as directed**.

11. Towel Shelf:

a. Description: Surface-mounted, guest-towel shelf with four 3/8-inch- (9-mm-) diameter **OR** 5/16-inch- (8-mm-) square, **as directed,** stainless steel tubes mounted in support arms.

1) Towel Bar: 1/4-inch (6-mm-) diameter **OR** 5/16-inch- (8-mm-) square, **as directed,** stainless-steel towel bar below shelf.

b. Length: 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed.**

c. Material and Finish: Polished brass-plated stainless steel tubes mounted in zinc alloy (zamac) support arms **OR** Polished chrome-plated stainless steel tubes mounted in zinc alloy (zamac) support arms **OR** Stainless steel, No. 7 finish (polished), **as directed**.

12. Towel Rack:

a. Description: Surface-mounted, guest-towel unit with approximately 1/4-inch- (6-mm-) diameter wire rings welded to upright wire bracket.

b. Capacity: 2 **OR** 3 **OR** 4, **as directed,** sets of bath towels, hand towels, and washcloths.

c. Nominal Height: 11 inches (279 mm) **OR** 17 inches (432 mm) **OR** 21 inches (533 mm), **as directed**.

d. Material and Finish: Polished brass-plated zinc alloy (zamac) **OR** Polished chrome-plated zinc alloy (zamac), **as directed**.

13. Retractable Clothesline:

a. Description: Surface-mounted rectangular **OR** circular, **as directed,** housing with minimum 72-inch- (1829-mm-) long, retractable, spring-actuated, synthetic clothesline and remote retention bracket.

b. Material and Finish Chrome-plated brass **OR** Stainless steel, No. 7 finish (polished), **as directed**.

14. Bottle Opener:

a. Description: Surface-mounted unit with standard **OR** vandal-resistant, **as directed,** fasteners.

b. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** Stainless steel, No. 7 finish (polished) **OR** Chrome-plated steel, **as directed**.

E. Healthcare Accessories

1. Specimen Pass-Through Cabinet:

a. Description: With self-closing doors on both sides, lock that prevents doors from both being opened at the same time, and removable stainless-steel tray.

b. Nominal Wall Opening: 12 by 11-1/4 inches (305 by 285 mm), width times height.

c. Material and Finish: Stainless steel, No. 4 finish (satin).

2. Specimen Pass-Through Box:

a. Description: With minimum 12-inch (305-mm) diameter turntable removable cylinder that revolves on stainless-steel self-lubricating ball bearing plates, and with mechanism to prevent over rotation of cylinder.

b. Nominal Wall Opening: 13-1/4 by 14 inches (335 by 355 mm), width times height.

c. Material and Finish: Stainless steel, No. 4 finish (satin).

d. Lockset: Tumbler type.

3. Bedpan and Urinal Cabinet:

a. Description: For storing one conventional size bedpan and one urinal bottle; with door that produces 1/2-inch (13-mm) opening at top and bottom of cabinet to allow air circulation.

b. Mounting: Recessed.

c. Nominal Wall Opening: 13-1/2 by 26-1/2 by 5 inches (340 by 670 by 130 mm), width times height times depth.

d. Material and Finish: Stainless steel, No. 4 finish (satin).

4. Bedpan and Urinal Rack:

a. Description: For storing one conventional size bedpan and one urinal bottle.

b. Mounting: Surface mounted.

c. Size: 12 by 27 inches (300 by 685 mm), width times height.
d. Material and Finish: Stainless steel, No. 4 finish (satin).

F. Warm-Air Dryers
1. Warm-Air Dryer:
a. Mounting: Recessed **OR** Semirecessed **OR** Surface mounted, **as directed**.
b. Operation: Touch-button **OR** Electronic-sensor, **as directed,** activated with timed power cut-off switch.
1) Operation Time: 30 to 40, **OR** 80, **as directed,** seconds.
c. Cover Material and Finish: Steel, with white enamel finish **OR** Cast iron, with enamel finish in color selected **OR** Chrome-plated steel **OR** Stainless steel, No. 4 finish (satin) **OR** Molded plastic, gray **OR** Molded plastic, white, **as directed**.
d. Electrical Requirements: 115 V, 13 A, 1500 W **OR** 115 V, 15 A, 1725 W **OR** 115 V, 20 A, 2300 W **OR** 208-240 V, 9-10 A, 1900-2300 W, **as directed**.

G. Childcare Accessories
1. Diaper-Changing Station:
a. Description: Horizontal **OR** Vertical, **as directed,** unit that opens by folding down from stored position and with child-protection strap.
1) Engineered to support a minimum of 250-lb (113-kg) static load when opened.
b. Mounting: Surface mounted, with unit projecting not more than 4 inches (100 mm) from wall when closed **OR** Semirecessed, with unit projecting not more than 1 inch (25 mm) from wall when closed, **as directed**.
c. Operation: By pneumatic shock-absorbing mechanism.
d. Material and Finish: High-density polyethylene in manufacturer's standard color **OR** High-density polyethylene with plastic laminate insert in color selected **OR** Stainless steel, No. 4 finish (satin), with replaceable insulated polystyrene tray liner and rounded plastic corners **OR** Stainless steel, No. 4 finish (satin), exterior shell with rounded plastic corners; high-density polyethylene interior in manufacturer's standard color, **as directed**.
e. Liner Dispenser: Built in.
2. Diaper-Pack Vendor:
a. Mounting: Surface mounted **OR** Recessed, **as directed**.
b. Minimum Capacity: 100 diaper packs.
c. Coin Operation: Coin slot preset for 1 U.S. dollar, adjustable up in 25-cent increments.
d. Material and Finish: Stainless steel, No. 4 finish (satin).
3. Child-Protection Seat:
a. Description: Unit that opens by folding down from stored position and with child-protection strap.
1) Engineered to support a minimum of 80-lb (36-kg), **OR** 150-lb (68-kg), **as directed,** static load when opened.
b. Mounting: Surface mounted, with unit projecting not more than 4-1/2 inches (114 mm), **OR** 6 inches (152 mm), **as directed,** from wall when closed.
c. Material and Finish: High-density polyethylene in manufacturer's standard color.

H. Underlavatory Guards
1. Material and Finish: Antimicrobial, molded-plastic, white.

I. Custodial Accessories
1. Utility Shelf:
a. Description: With exposed edges turned down not less than 1/2 inch (12.7 mm) and supported by two triangular brackets welded to shelf underside.
b. Size: 16 inches (406 mm) long by 6 inches (152 mm) deep.
c. Material and Finish: Not less than nominal 0.05-inch- (1.3-mm-) thick stainless steel, No. 4 finish (satin).
2. Mop and Broom Holder:

a. Description: Unit with shelf, hooks, holders, and rod suspended beneath shelf.
b. Length: 36 inches (914 mm).
c. Hooks: Three.
d. Mop/Broom Holders: Four, spring-loaded, rubber hat, cam type.
e. Material and Finish: Stainless steel, No. 4 finish (satin).
1) Shelf: Not less than nominal 0.05-inch- (1.3-mm-) thick stainless steel.
2) Rod: Approximately 1/4-inch- (6-mm-) diameter stainless steel.

3. Paper Towel (Folded) Dispenser:
a. Mounting: Recessed **OR** Semirecessed **OR** Surface mounted, **as directed**.
b. Minimum Capacity: 400 C-fold or 525 multifold towels **OR** 600 C-fold or 800 multifold towels **OR** 400 single-fold towels, **as directed**.
c. Material and Finish: Stainless steel, No. 4 finish (satin) **OR** ABS plastic, gray, **as directed**.
d. Lockset: Tumbler type.
e. Refill Indicators: Pierced slots at sides or front.

4. Paper Towel (Roll) Dispenser:
a. Description: Lever-actuated mechanism permits controlled delivery of paper rolls in preset lengths per stroke.
b. Mounting: Recessed **OR** Semirecessed **OR** Surface mounted, **as directed**.
c. Minimum Capacity: 8-inch (203-mm) wide, 800-foot (244-m) long roll.
d. Material and Finish: Stainless steel, No. 4 finish (satin), **OR** ABS plastic, gray, **as directed**.
e. Lockset: Tumbler type.

5. Liquid-Soap Dispenser:
a. Description: Designed for dispensing soap in liquid or lotion **OR** lather, **as directed,** form.
b. Mounting: Deck mounted on vanity **OR** Deck mounted on lavatory **OR** Horizontally oriented, recessed **OR** Horizontally oriented, surface mounted **OR** Vertically oriented, surface mounted, **as directed**.
c. Capacity: Capacity in oz. (mL), **as directed.**
d. Materials: Valve and reservoir materials and finishes, **as directed**.
e. Lockset: Tumbler type.
f. Refill Indicator: Window type.

J. Fabrication
1. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

1.3 EXECUTION

A. Installation
a. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
b. Grab Bars: Install to withstand a downward load of at least 250 lbf (1112 N), when tested according to method in ASTM F 446.

END OF SECTION 10810

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SECTION 10810a - DETENTION TOILET ACCESSORIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for detention toilet accessories. Product shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Safety hooks.
b. Shelves.
c. Combination shelves with safety hooks.
d. Miscellaneous toilet accessories.
e. Stainless-steel mirrors.
f. Grab bars.
g. Shower seats.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
a. Product Data for Credit EQ 4.1: For security sealants, including printed statement of VOC content.
3. Samples: For each type of detention toilet accessory indicated.
4. Product Schedule: Indicate types, quantities, sizes, and installation locations by room.
5. Coordination Drawings: Drawings showing location of each built-in anchor supporting detention toilet accessories, including anchors to be installed as work of other Sections, drawn to scale and coordinating anchorage with detention toilet accessories.
6. Welding certificates.
7. Maintenance data.
8. Warranties: Sample of special warranties.
9. Other Informational Submittals:
a. Examination reports documenting inspection of substrates, areas, and conditions.
b. Anchor inspection reports documenting inspections of built-in and cast-in anchors.
c. Field quality-control certification signed by Contractor and Detention Specialist.

D. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. AWS D1.3, "Structural Welding Code - Sheet Steel."
c. AWS D1.6, "Structural Welding Code - Stainless Steel."
2. Preinstallation Conference: Conduct conference at Project site.
3. Coordination Meetings: Conduct coordination meetings at Project site to comply with requirements in Division 01 Section "Special Project Procedures For Detention Facilities".

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace detention toilet accessories that fail in materials or workmanship within two years from date of Substantial Completion.

1.2 PRODUCTS

A. Materials
1. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, CS (Commercial Steel), Type B.
2. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, CS (Commercial Steel), Type B; with G60 (Z180) zinc (galvanized) coating designation.
3. Stainless-Steel Sheet: ASTM A 666 or ASTM A 240/A 240M, austenitic stainless steel, Type 304; Type 430 for mirrors.
4. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
5. Concealed Bolts: ASTM A 307, Grade A unless otherwise indicated.
6. Cast-in-Place Anchors in Concrete: Anchors of type indicated below, fabricated from corrosion-resistant materials capable of sustaining, without failure, a load equal to 4 times the load imposed, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
   a. Threaded or wedge type; galvanized ferrous castings, either ASTM A 47/A 47M malleable iron or ASTM A 27/A 27M cast steel. Provide bolts, washers, and shims as needed, hot-dip galvanized per ASTM A 153/A 153M.
7. Embedded Plate Anchors: Fabricated from steel shapes and plates, minimum 3/16 inch (4.8 mm) thick; with minimum 1/2-inch- (12.7-mm-) diameter headed studs welded to back of plate.
8. Proprietary Built-in Masonry Anchors: Fabricated from 0.134-inch (3.41-mm) nominal-thickness steel sheet **OR** 1/4-inch (6.3-mm) nominal-thickness steel plate **OR** 1/2-inch (12.7-mm) nominal-thickness steel plate, **as directed**, into 6-inch- (152-mm-) **OR** 8-inch- (203-mm-), **as directed**, deep blocks matching size of concrete masonry units; with weld nuts attached on inside to receive field-bolted attachments, **as directed**.
   a. Finish: Factory primed for field painting for anchors with field-welded attachments **OR** Polyester powder coat for anchors with bolted attachments **OR** Epoxy paint for anchors with bolted attachments, **as directed**.
9. Welding Rods and Bare Electrodes: Select according to AWS specifications.

B. Security Sealants
1. Manufacturer's standard, high-modulus, nonsag, two-part, pick-proof, epoxy sealant, with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24), recommended for sealing nonmoving interior joints in security applications.

C. Security Fasteners
1. Fasteners that are operable only by tools produced by fastener manufacturer or other licensed fabricator for use on specific type of fastener.
2. Provide drive-system type, head style, material, and protective coating as required for assembly, installation, and strength, and as follows:
   a. Drive-System Types: Pinned Torx-Plus **OR** Pinned Torx, **as directed**.
   b. Fastener Strength: 120,000 psi (827 MPa).
   c. Socket Button Head Fasteners:
      1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
      2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
   d. Socket Flat Countersunk Head Fasteners:
      1) Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
      2) Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
   e. Socket Head Cap Fasteners:
      1) Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
      2) Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
   f. Protective Coatings for Heat-Treated Alloy Steel:
      1) Zinc and clear trivalent chromium, where indicated.
      2) Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

D. Detention Safety Hooks

1. Individual, Curved, Detention Safety Hook: 0.188-inch (4.77-m) nominal-thickness, stainless-steel curved hook held by 0.141-inch- (3.58-mm-) **OR** 0.109-inch- (2.77-mm-), **as directed**, thick, stainless-steel bracket punched with not less than 2 holes for fastening with security fastener. Provide friction washer assembly, adjustable with a nonremovable security screw that maintains pressure on hook and allows hook to pivot when load exceeds preset limit. Provide No. 4 finish.
2. Individual, Straight, Detention Safety Hook: 3/8-inch- (9.5-mm-) **OR** 1/4-inch- (6.3-mm-), **as directed**, diameter, stainless-steel straight hook held by 0.109-inch- (2.77-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel mounting plate approximately 4 inches (102 mm) square. Provide pivoting assembly that maintains pressure on hook and snaps down when load exceeds 8 lbf (35.6 N). Provide No. 4 finish.
   a. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.
3. Multiple, Curved, Safety Hook Strip: Minimum 5-1/2-inch- (140-mm-) high backplate by length indicated, formed from 0.125-inch- (3.18-mm-) **OR** 0.109-inch- (2.77-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel sheet. Provide 0.188-inch- (4.77-mm-) thick, stainless-steel hooks attached to backplate; with each hook having a friction washer assembly, adjustable with a nonremovable security screw that maintains pressure on hook and allows hook to pivot when load exceeds preset limit. Provide No. 4 finish.
   a. Configuration: 16 inches (406 mm) long with 2 hooks **OR** 18 inches (457 mm) long with 4 hooks **OR** 21 inches (533 mm) long with 4 hooks **OR** 24 inches (610 mm) long with 3 hooks **OR** 32 inches (813 mm) long with 4 hooks, **as directed**.
   b. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.
4. Multiple, Straight, Safety Hook Strip: Minimum 5-1/2-inch- (140-mm-) high backplate by length indicated, formed from 0.141-inch- (3.58-mm-) **OR** 0.109-inch- (2.77-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel sheet. Provide 3/8-inch- (9.5-mm-) **OR** 1/4-inch- (6.3-mm-), **as directed**, diameter, stainless-steel straight hooks attached to backplate. Provide pivoting assembly that maintains pressure on hook and snaps down when load exceeds 8 lbf (35.6 N). Provide No. 4 finish.
   a. Configuration: 16 inches (406 mm) long with 2 hooks **OR** 18 inches (457 mm) long with 4 hooks **OR** 24 inches (610 mm) long with 3 hooks **OR** 32 inches (813 mm) long with 4 hooks, **as directed**.
   b. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

E. Detention Shelves

1. Surface-Mounted, Steel Detention Shelf: Minimum 6 inches high by 8 inches (152 mm high by 203 mm) deep by 16 inches (406 mm) **OR** 24 inches (610 mm) **OR** 32 inches (813 mm), **as directed**, long; formed from 0.138-inch (3.50-mm) **OR** 0.108-inch (2.74-mm), **as directed**, nominal-thickness, metallic-coated steel sheet; with welded side gussets and minimum 1-inch (25.4-mm) flanged front edge; with back punched for fastening to wall with security fasteners. Provide factory priming for field-painted **OR** baked-enamel, **as directed**, finish.
2. Surface-Mounted, Stainless-Steel Detention Shelf: Minimum 5-1/2 inches high by 8 inches (140 mm high by 203 mm) deep by 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**, long; formed from 0.078-inch- (1.98-mm-) thick, stainless-steel sheet; with welded side gussets and hemmed front edge. Provide No. 4 finish.
   a. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.
3. Recessed Detention Shelf: Minimum inside dimensions of 16 inches (406 mm) wide by 5 inches high by 4 inches (127 mm high by 102 mm) deep; formed from 0.062-inch- (1.57-mm-) thick, stainless-steel sheet; with 1-inch- (25.4-mm-) wide flanged front edge. Secure to wall with rear-mounting steel strap and adjustment bolts. Provide No. 4 finish.

F. Combination Detention Shelves With Safety Hooks

1. Steel Detention Shelf with Multiple, Curved Safety Hooks: Minimum 6 inches high by 8 inches (152 mm high by 203 mm) deep by length indicated, formed from 0.138-inch (3.50-mm) **OR** 0.108-inch (2.74-mm), **as directed**, nominal-thickness, metallic-coated steel sheet, with welded side gussets and hemmed or flanged front edge. Provide 0.138-inch (3.50-mm) nominal-thickness, zinc-plated-steel curved hooks held by 0.1265-inch- (3.21-mm-) thick steel brackets welded to backplate, with each hook having a friction washer assembly, adjustable with a nonremovable security screw that maintains pressure on hook and allows hook to pivot when load exceeds preset limit. Provide factory priming for field-painted **OR** baked-enamel, **as directed**, finish.
   a. Configuration: 16 inches (406 mm) long with 2 hooks **OR** 24 inches (610 mm) long with 3 hooks **OR** 32 inches (813 mm) long with 4 hooks, **as directed**.
   b. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.
2. Stainless-Steel Detention Shelf with Multiple, Curved Safety Hooks: Minimum 5-1/2 inches high by 8 inches (140 mm high by 203 mm) deep by length indicated; formed from 0.078-inch- (1.98-mm-) thick, stainless-steel sheet; with welded side gussets and hemmed or flanged front edge. Provide 0.141-inch (3.58-mm) stainless-steel curved hooks held by 0.141-inch- (3.58-mm-) thick stainless-steel brackets welded to backplate, with each hook having a friction washer assembly, adjustable with a nonremovable security screw that maintains pressure on hook and allows hook to pivot when load exceeds preset limit. Provide No. 4 finish.
   a. Configuration: 16 inches (406 mm) long with 2 hooks **OR** 18 inches (457 mm) long with 4 hooks **OR** 24 inches (610 mm) long with 3 hooks **OR** 32 inches (813 mm) long with 4 hooks, **as directed**.
   b. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.
3. Stainless-Steel Detention Shelf with Multiple, Straight Safety Hooks: Minimum 5-1/2 inches high by 8 inches (140 mm high by 203 mm) deep by length indicated; formed from 0.078-inch- (1.98-mm-) thick, stainless-steel sheet; with welded side gussets and hemmed or flanged front edge. Provide 3/8-inch- (9.5-mm-) **OR** 1/4-inch- (6.3-mm-), **as directed**, diameter, stainless-steel straight hooks held by 0.109-inch- (2.77-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel mounting plate. Provide pivoting assembly that maintains pressure on hook and snaps down when load exceeds 8 lbf (35.6 N). Provide No. 4 finish.
   a. Configuration: 16 inches (406 mm) long with 2 hooks **OR** 18 inches (457 mm) long with 4 hooks **OR** 24 inches (610 mm) long with 3 hooks **OR** 32 inches (813 mm) long with 4 hooks, **as directed**.
   b. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

G. Miscellaneous Detention Toilet Accessories
1. Recessed, Detention Toilet Tissue Dispenser: Minimum 5-inch diameter by 4-1/2 inches (127-mm diameter by 114 mm) deep; formed from 0.062-inch- (1.57-mm-) thick, stainless-steel sheet. Secure to wall with rear-mounting steel strap and adjustment bolts. Provide No. 4 finish.
   a. Face: 1-inch (25.4-mm) lip around entire face **OR** 7-inch- (178-mm-) square face flange, **as directed**.
2. Recessed, Detention Soap Dish: Minimum inside dimensions of 5-3/4 inches wide by 4-1/2 inches high by 2-1/2 inches (146 mm wide by 114 mm high by 64 mm) deep with 3/4-inch (19-mm) lip around entire face; formed from 0.062-inch- (1.57-mm-) **OR** 0.050-inch- (1.27-mm-), **as directed**, thick, stainless-steel sheet. Secure to wall with rear-mounting steel strap and adjustment bolts. Provide No. 4 finish.

H. Detention Mirrors
1. Small, Framed Detention Mirror: Approximately 9-1/2 inches wide by 11 inches (241 mm wide by 279 mm) high; formed from 0.038-inch- (0.95-mm-) thick, stainless-steel sheet with fiberboard backing; enclosed in a frame formed from 0.064-inch (1.63-mm) nominal-thickness, zinc-plated

steel sheet; with round corners. Fabricate frame with welded and ground corners or from one piece of metal. Provide No. 8 **OR** 4, **as directed**, finish for mirror, chrome plating for frame.

a. Mounting: Front mounting with security fasteners to 0.168-inch (4.27-mm) nominal-thickness, metallic-coated steel mounting plate **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

2. Small, Integrally Framed Detention Mirror: Approximately 9-1/2 inches wide by 11 inches (241 mm wide by 279 mm) high; with mirror and integral frame formed from a single sheet of 0.038-inch- (0.95-mm-) **OR** 0.062-inch- (1.57-mm-), **as directed**, thick stainless steel; with round corners. Provide No. 8 **OR** 4, **as directed**, finish for mirror, chrome plating for frame.

a. Mounting: Front mounting with security fasteners to 0.168-inch (4.27-mm) nominal-thickness, metallic-coated steel mounting plate **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

3. Large, Framed Detention Mirror with Square Corners: Minimum 11 inches wide by 16 inches (279 mm wide by 406 mm) high; formed from 0.038-inch- (0.95-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel sheet with fiberboard backing and No. 8 **OR** No. 4, **as directed**, finish; enclosed in a metal frame.

a. Frame: Formed from 0.064-inch (1.63-mm) nominal-thickness, chrome-plated steel **OR** 0.062-inch- (1.57-mm-) thick, stainless-steel **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel, **as directed**, sheet. Fabricate frame with welded and ground corners or from one piece of metal.

b. Mounting: Front mounting with security fasteners to 0.168-inch (4.27-mm) nominal-thickness, metallic-coated steel mounting plate **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

4. Large, Framed Detention Mirror with Round Corners: Minimum 11 inches wide by 16 inches (279 mm wide by 406 mm) high, formed from a single sheet of 0.038-inch- (0.95-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick stainless steel with No. 8 **OR** No. 4, **as directed**, finish; enclosed in a metal frame.

a. Frame: Formed from 0.064-inch (1.63-mm) nominal-thickness, chrome-plated steel **OR** 0.078-inch- (1.98-mm-) thick, stainless-steel, **as directed**, sheet. Fabricate frame with welded and ground corners or from one piece of metal.

b. Mounting: Front mounting with security fasteners to 0.168-inch (4.27-mm) nominal-thickness, metallic-coated steel mounting plate **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

5. Large, Integrally Framed Detention Mirror with Round Corners: Minimum 11 inches wide by 16 inches (279 mm wide by 406 mm) high; with mirror and integral frame formed from 0.038-inch- (0.95-mm-) **OR** 0.062-inch- (1.57-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel sheet; with round corners. Provide No. 8 **OR** 4, **as directed**, finish for mirror, chrome plating for frame.

a. Mounting: Front mounting with security fasteners to 0.168-inch (4.27-mm) nominal-thickness, metallic-coated steel mounting plate **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

I. Detention Grab Bars

1. Grab Bars: 1-1/2 inches (38.1 mm) in diameter; formed from 0.038-inch- (0.95-mm-) thick, stainless-steel tubing, with 3-inch- (76.2-mm-) diameter flanges formed from 0.125-inch- (3.18-mm-) thick, stainless steel. Closure plates formed from 0.125-inch- (3.18-mm-) thick, stainless steel. All-welded construction. Provide No. 4 finish.

a. Length: As indicated on Drawings **OR** 36 inches (914 mm) long, **as directed**.

b. Mounting: Front mounting with security fasteners **OR** Chase mounting with welded anchor nuts on backplate, **as directed**.

J. Detention Shower Seats

1. Shower Seats: Double-pan retractable, recessed shower seat with recessed handle. Approximately 16-inch by 16-inch (406-mm by 406-mm) overall size formed from 0.062-inch- (1.57-mm-) **OR** 0.078-inch- (1.98-mm-), **as directed**, thick, stainless-steel sheet. Seat pivots on

solid 0.375-inch- (9.5-mm-) diameter stainless-steel rod and self-latches when closed. Minimum 750 lb. (340 kg) loading capacity. Provide No. 4 finish.

K. Fabrication
1. Coordinate dimensions and attachment methods of detention toilet accessories with those of adjoining construction to produce integrated assemblies with closely fitting joints and with edges and surfaces aligned unless otherwise indicated.
2. Shear and punch metals cleanly and accurately. Remove burrs.
3. Form edges and corners to be free of sharp edges and rough areas. Fold back exposed edges of unsupported sheet metal to form a 1/2-inch- (12.7-mm-) wide hem on the concealed side, or ease edges to a radius of approximately 1/32 inch (0.8 mm) and support with concealed stiffeners.
4. Form metal in maximum lengths to minimize joints. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
5. Weld corners and seams continuously to comply with referenced AWS standard and the following:
   a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   b. Obtain fusion without undercut or overlap.
   c. Remove welding flux immediately.
   d. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
   e. Weld before finishing components to greatest extent possible. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
6. Provide for anchorage of type indicated; coordinate with supporting structure. Fabricate and space anchoring devices to secure detention toilet accessories rigidly in place and to support expected loads. Build in straps, plates, and brackets as needed to support and anchor fabricated items to adjoining construction. Reinforce formed-metal units as needed to attach and support other construction.
7. Cut, reinforce, drill, and tap detention toilet accessories to receive hardware, security fasteners, and similar items.
8. Form exposed work true to line and level with accurate angles and surfaces. Grind off and ease edges unless otherwise indicated.
9. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Use exposed security fasteners of type indicated or, if not indicated, flat-head (countersunk) security fasteners. Locate joints where least conspicuous.

L. Finishes
1. Finish detention toilet accessories after assembly.
2. Steel Finishes:
   a. Surface Preparation: Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
   b. Factory Priming for Field-Painted Finish: Apply manufacturer's standard prime coat immediately after surface preparation and pretreatment.
   c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-enamel finish consisting of prime coat and thermosetting topcoat. Comply with paint manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 1.2 mils (0.03 mm).
      1) Color and Gloss: As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   d. Chromium Plating: ASTM B 456, Service Condition Number SC 2 (moderate service), nickel plus chromium electrodeposited on base metal.
3. Stainless-Steel Finishes: Remove tool and die marks and stretch lines or blend into finish.

a. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

1.3 EXECUTION

A. Installation
1. Fastening to In-Place Construction: Provide anchorage devices and fasteners where necessary for securing detention toilet accessories to in-place construction. Include threaded fasteners for concrete and masonry inserts, security fasteners, and other connectors.
2. Provide temporary bracing or anchors in formwork for items that are to be built into concrete or masonry or similar construction.
3. Apply security sealant around perimeter in a continuous ribbon on back of detention toilet accessories before installation.
4. Security Fasteners: Install detention toilet accessories using security fasteners with head style appropriate for installation requirements, strength, and finish of adjacent materials. Provide stainless-steel security fasteners in stainless-steel materials, **as directed**.

B. Field Quality Control
1. Inspect installed products to verify compliance with requirements. Prepare inspection reports and indicate compliance with and deviations from the Contract Documents.
2. Remove and replace detention work where inspections indicate that work does not comply with specified requirements.
3. Perform additional inspections to determine compliance of replaced or additional work. Prepare inspection reports.
4. Prepare field quality-control certification that states installed products and their installation comply with requirements in the Contract Documents.

C. Adjusting And Cleaning
1. Remove temporary labels and protective coatings.
2. Adjust safety hooks to release with application of 8-lbf (35.6-N) load.
3. Painting: Immediately after erection, clean bolted connections and abraded areas of shop paint, and paint exposed areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
4. Touchup Painting: Cleaning and touchup painting of bolted connections and abraded areas of shop paint are specified in Division 07..

END OF SECTION 10810a

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Task	Specification	Specification Description
10810	01352	No Specification Required
10811	10810	Toilet And Bath Accessories
10811	10810a	Detention Toilet Accessories
10812	10810	Toilet And Bath Accessories

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Task	Specification	Specification Description
11021	08710a	Detention Door Hardware
11131	01352	No Specification Required

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SECTION 11132 - PROJECTION SCREENS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for projection screens. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Manually operated projection screens.
b. Electrically operated projection screens and controls.
c. Rigid rear-projection screens.

C. Definitions
1. Gain of Front-Projection Screens: Ratio of light reflected from screen material to that reflected perpendicularly from a magnesium carbonate surface as determined per SMPTE RP 94.
2. Gain of Rear-Projection Screens: Ratio of light refracted by screen material to that reflected perpendicularly from a magnesium carbonate surface as determined per SMPTE RP 94, except that for measuring luminance of test screen, projection lamp shall be placed behind screen same distance as it was placed in front of magnesium carbonate surface for measuring luminance of reference standard.
3. Half-Gain Angle: The angle, measured from the axis of the screen surface to the most central position on a perpendicular plane through the horizontal centerline of the screen where the gain is half of the peak gain.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For projection screens. Show layouts and types of projection screens. Include the following:
a. For manually operated projection screens:
1) Drop lengths.
2) Anchorage details.
3) Accessories.
b. For electrically operated projection screens and controls:
1) Location of screen centerline relative to ends of screen case.
2) Location of wiring connections for electrically operated units.
3) Location of seams in viewing surfaces.
4) Drop lengths.
5) Anchorage details, including connection to supporting structure for suspended units.
6) Details of juncture of exposed surfaces with adjacent finishes.
7) Accessories.
8) Wiring diagrams.
c. For rigid rear-projection screens:
1) Frame details.
2) Anchorage details.
3) Details of juncture of exposed surfaces with adjacent finishes.
4) Accessories.
3. Maintenance Data: For projection screens to include in maintenance manuals.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Delivery, Storage, And Handling
1. Environmental Limitations: Do not deliver or install projection screens until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Store rear-projection screens in manufacturer's protective packaging and according to manufacturer's written instructions.

1.2 PRODUCTS

A. Manually Operated Projection Screens
1. General: Manufacturer's standard spring-roller-operated units, consisting of case, screen, mounting accessories, and other components necessary for a complete installation.
   a. Screen Mounting: Top edge securely anchored to a 3-inch- (75-mm-) diameter, rigid steel roller; bottom edge formed into a pocket holding a tubular metal slat, with ends of slat protected by plastic caps, and with a saddle and pull attached to slat by screws.
   b. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen connected to edge of screen by tabs to pull screen flat horizontally. In lieu of tab tensioning, screens may be constructed from vinyl-coated screen cloth that contains horizontal stiffening monofilaments to resist edge curling, **as directed**.
2. Bracket-Mounted or Ceiling-Suspended, Metal-Encased, Manually Operated Screens: Units designed and fabricated for suspending from wall brackets or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with vinyl covering or baked-enamel finish and matching end caps. Provide mounting brackets unless otherwise indicated.
3. Surface-Mounted, Metal-Encased, Manually Operated Screens: Units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide units with matching end caps and concealed mounting.
4. Surface-Mounted, Wood-Finished, Manually Operated Screens: Units designed and fabricated for surface mounting on wall or ceiling; with flat back design, hardwood finish, and concealed mounting brackets.
   a. Hardwood: Oak **OR** Walnut **OR** Mahogany **OR** Cherry **OR** As selected from manufacturer's full range of species, **as directed**.
   b. Finish: As selected from manufacturer's full range.

B. Electrically Operated Projection Screens
1. General: Manufacturer's standard units consisting of case, screen, motor, controls, mounting accessories, and other components necessary for a complete installation. Provide units that are listed and labeled as an assembly by UL or another testing and inspecting agency acceptable to authorities having jurisdiction, **as directed**.
   a. Controls: Remote, key-operated, **as directed**, three-position control switch installed in recessed device box with flush cover plate matching other electrical device cover plates in room where switch is installed.
      1) Provide two **OR** three, **as directed**, control switches for each screen.
      2) Provide number of control switches indicated for each screen.
      3) Provide power supply for low-voltage systems if required.
      4) Provide locking cover plates for switches.
      5) Provide key-operated, power-supply switch.

6) Provide infrared **OR** radio-frequency, **as directed**, remote control consisting of battery-powered transmitter and receiver.
7) Provide video interface control for connecting to projector. Projector provides signal to raise or lower screen.

b. Motor in Roller: Instant-reversing motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, preset limit switches to automatically stop screen in up and down positions, and positive-stop action to prevent coasting. Mount motor inside roller with vibration isolators to reduce noise transmission.

c. End-Mounted Motor: Instant-reversing, gear-drive motor of size and capacity recommended by screen manufacturer; with permanently lubricated ball bearings, automatic thermal-overload protection, preset limit switches to automatically stop screen in up and down positions, and positive-stop action to prevent coasting. Locate motor in its own compartment on right end of screen unless otherwise indicated **OR** on left end of screen unless otherwise indicated **OR** on end of screen indicated, **as directed**.

d. Screen Mounting: Top edge securely anchored to rigid metal roller and bottom edge formed into a pocket holding a 3/8-inch- (9.5-mm-) diameter metal rod with ends of rod protected by plastic caps.
1) Roller for end-mounted motor supported by self-aligning bearings in brackets.
2) Roller for motor in roller supported by vibration- and noise-absorbing supports.

e. Tab Tensioning: Provide units that have a durable low-stretch cord, such as braided polyester, on each side of screen connected to edge of screen by tabs to pull screen flat horizontally. In lieu of tab tensioning, screens may be constructed from vinyl-coated screen cloth that contains horizontal stiffening monofilaments to resist edge curling.

2. Surface-Mounted, Metal-Encased, Electrically Operated Screens: Motor-in-roller **OR** End-mounted motor, **as directed**, units designed and fabricated for surface mounting on wall or ceiling, fabricated from formed-steel sheet not less than 0.027 inch (0.7 mm) thick or from aluminum extrusions; with flat back design and vinyl covering or baked-enamel finish. Provide with matching end caps and concealed mounting.

3. Surface-Mounted, Wood-Finished, Electrically Operated Screens: Motor in roller units designed and fabricated for surface mounting on wall or ceiling; with flat back design, hardwood finish, and concealed mounting brackets.
a. Hardwood: Oak **OR** Walnut **OR** Mahogany **OR** Cherry **OR** As selected from manufacturer's full range of species, **as directed**.
b. Finish: As selected from manufacturer's full range.

4. Suspended, Electrically Operated Screens without Ceiling Closure: Motor-in-roller **OR** End-mounted motor, **as directed**, units designed and fabricated for suspended mounting, with bottom of case entirely or partially open under screen compartment.
a. Provide metal or metal-lined motor enclosure on units with end-mounted motor.
b. Provide metal or metal-lined wiring compartment on units with motor in roller.
c. Screen Case: Made from metal **OR** metal and fire-retardant materials **OR** metal, wood, wood products, and fire-retardant materials, **as directed**.
d. Provide screen case with trim flange to receive ceiling finish **OR** constructed to be installed with underside flush with ceiling **OR** constructed to be installed with ceiling finish applied to underside, **as directed**.
e. Finish on Exposed Surfaces: Prime painted **OR** Vinyl covering or baked enamel, **as directed**.

5. Suspended, Electrically Operated Screens with Automatic Ceiling Closure: Motor-in-roller **OR** End-mounted motor, **as directed**, units designed and fabricated for suspended mounting; with bottom of case composed of two panels, fully enclosing screen, motor, and wiring; one panel hinged and designed to open and close automatically when screen is lowered and fully raised, the other removable or openable for access to interior of case.
a. Provide metal or metal-lined motor enclosure on units with end-mounted motor.
b. Provide metal or metal-lined wiring compartment on units with motor in roller.
c. Screen Case: Made from metal **OR** metal and fire-retardant materials **OR** metal, wood, wood products, and fire-retardant materials, **as directed**.

d. Provide screen case with trim flange to receive ceiling finish **OR** constructed to be installed with underside flush with ceiling **OR** constructed to be installed with ceiling finish applied to underside, **as directed**.

e. Finish on Exposed Surfaces: Prime painted **OR** Vinyl covering or baked enamel, **as directed**.

C. Front-Projection Screen Material

1. Matte-White Viewing Surface: Peak gain not less than 0.9, and gain not less than 0.8 at an angle of 50 degrees from the axis of the screen surface.
2. Matte-Gray Viewing Surface: Peak gain not less than 0.8, and half-gain angle of not less than 50 degrees from the axis of the screen surface.
3. Glass-Beaded Viewing Surface: Peak gain not less than 2.0, and half-gain angle of at least 15 degrees from the axis of the screen surface.
4. Matte Reflective Viewing Surface: Peak gain not less than 1.3, and half-gain angle of at least 40 degrees from the axis of the screen surface.
5. Wide-Angle Reflective Viewing Surface: Peak gain not less than 1.5, and half-gain angle of at least 35 degrees from the axis of the screen surface.
6. Multipurpose Reflective Viewing Surface: Peak gain not less than 1.8, and half-gain angle of at least 25 degrees from the axis of the screen surface.
7. High-Gain Reflective Viewing Surface: Peak gain not less than 2.5, and half-gain angle of at least 20 degrees from the axis of the screen surface.
8. Material: Vinyl-coated, glass-fiber fabric or vinyl sheet.
9. Mildew-Resistance Rating: 0 or 1 when tested according to ASTM G 21.
10. Flame Resistance: Passes NFPA 701.
11. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.
12. Seams: Where length of screen indicated exceeds maximum length produced without seams in material specified, provide screen with horizontal seam placed as follows:
    a. At top **OR** bottom, **as directed**, of screen at juncture between extra drop length and viewing surface.
    b. In location indicated.
13. Seamless Construction: Provide screens, in sizes indicated, without seams.
14. Edge Treatment: Black **OR** Without black, **as directed**, masking borders.
15. Size of Viewing Surface: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
16. Provide extra drop length of dimensions and at locations indicated.
    a. Color: Same as viewing surface **OR** Black, **as directed**.

D. Flexible Rear-Projection Screen Material

1. Wide-Angle Screens: Peak gain not less than 1.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.
2. Moderate-Gain Screens: Peak gain not less than 1.3, and half-gain angle of at least 30 degrees from the axis of the screen surface.
3. High-Gain Screens: Peak gain not less than 1.8, and half-gain angle of at least 15 degrees from the axis of the screen surface.
4. Material: Coated vinyl sheet.
5. Mildew-Resistance Rating: 0 or 1 when tested according to ASTM G 21.
6. Flame Resistance: Passes NFPA 701.
7. Flame-Spread Index: Not greater than 75 when tested according to ASTM E 84.
8. Seamless Construction: Provide screens, in sizes indicated, without seams.
9. Size of Viewing Surface: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.

10. Provide extra drop length of dimensions and at locations indicated.
    a. Color: Same as viewing surface **OR** Black, **as directed**.

E. Optically Coated Rigid Rear-Projection Screens
1. Screen Substrate: Optically clear substrate complying with the following requirements:
    a. Clear float glass complying with ASTM C 1036 for Type I (transparent glass, flat), Class 1 (clear), and Quality q3 (glazing select), 6.0 mm thick **OR** 10.0 mm thick **OR** 12.0 mm thick **OR** thickness as indicated, **as directed**.
    b. Colorless, transparent, cast-acrylic sheet with a luminous transmittance of 92 percent per ASTM D 1003 and complying with ASTM D 4802, Category A-1 (cell cast), Finish 1 (smooth or polished), 1/4 inch (6.4 mm) thick **OR** 3/8 inch (9.5 mm) thick **OR** 1/2 inch (12.7 mm) thick **OR** thickness as indicated, **as directed**.
    c. Fresnel lens cast from colorless, transparent, acrylic with a luminous transmittance of 92 percent per ASTM D 1003 and complying with ASTM D 4802, Category A-1 (cell cast), Finish 1 (smooth or polished) on one side and Finish 2 (patterned) on other side, 1/4 inch (6.4 mm) thick **OR** 3/8 inch (9.5 mm) thick **OR** 1/2 inch (12.7 mm) thick **OR** thickness as indicated, **as directed**.
2. Optical Coating: Durable, washable coating bonded to one side of substrate.
3. Wide-Angle Screens: Peak gain not less than 1.0, and half-gain angle of at least 35 degrees from the axis of the screen surface.
4. Moderate-Gain Screens: Peak gain not less than 1.3, and half-gain angle of at least 30 degrees from the axis of the screen surface.
5. General-Purpose Screens: Peak gain of not less than 1.8, and half-gain angle of at least 28 degrees from the axis of the screen surface.
6. High-Gain Screens: Peak gain not less than 2.0, and half-gain angle of at least 20 degrees from the axis of the screen surface.
7. Optical Tint: High-contrast dark gray **OR** Medium neutral gray **OR** Neutral white **OR** Manufacturer's standard, **as directed**.
8. Protective Coating: Provide formulation designed by screen manufacturer as a permanent topcoat over optical coatings to protect against normal abrasion before, during, and after installation.
9. Writing-Surface Coating: Provide screen manufacturer's protective coating, designed as a writing surface for dry-erase markers, on front of screen.
10. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.

F. High-Performance Rigid Rear-Projection Screens
1. High-Performance Screens, General: Acrylic screen with Fresnel lens on rear surface and linear lenses on front surface.
    a. Screen Substrate: Optically clear acrylic with a luminous transmittance of 92 percent per ASTM D 1003 and complying with ASTM D 4802, Category A-1 (cell cast), Finish 2 (patterned), 1/4 inch (6.4 mm) thick **OR** 3/8 inch (9.5 mm) thick **OR** 1/2 inch (12.7 mm) thick **OR** thickness as indicated, **as directed**.
2. Performance:
    a. Peak gain not less than 3.0 **OR** 4.0, **as directed**, and horizontal half-gain angle of at least 50 degrees from the axis of the screen surface.
    b. Peak gain of 3.5 **OR** 4.0, **as directed**, and horizontal half-gain angle of at least 30 degrees from the axis of the screen surface.
    c. Performance: Peak gain of 5.0, and horizontal half-gain angle of at least 25 degrees from the axis of the screen surface.
    d. Performance: Peak gain not less than 1.5 **OR** 3.0, **as directed**, and horizontal half-gain angle of at least 20 degrees from the axis of the screen surface.
3. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.

G. Rigid Rear-Projection Screen Accessories
1. Factory Frames: Screen manufacturer's standard frames of profile indicated, fabricated to sizes required to fit screens from aluminum extrusions complying with ASTM B 221 (ASTM B 221M) for 6063-T5 alloy and temper.
a. Class II, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
b. Class II, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker) complying with AAMA 611.
1) Color: Black **OR** Dark bronze **OR** Either black or dark bronze, as standard with manufacturer, **as directed**.
2. Glazing Accessories for Factory Frames: Provide gaskets and setting blocks with proven record of compatibility with screen and frame surfaces, of sizes and shapes to accommodate thickness of screen indicated and to fit glazing channel provided.
3. Glazing Accessories for Field-Framed Screens: Provide materials compatible with screen and frame surfaces while complying with applicable requirements in Division 08 Section "Glazing".

1.3 EXECUTION

A. Front-Projection Screen Installation
1. Install front-projection screens at locations indicated to comply with screen manufacturer's written instructions.
2. Install front-projection screens with screen cases in position and in relation to adjoining construction indicated. Securely anchor to supporting substrate in a manner that produces a smoothly operating screen with vertical edges plumb and viewing surface flat when screen is lowered.
a. Install low-voltage controls according to NFPA 70 and complying with manufacturer's written instructions.
1) Wiring Method: Install wiring in raceway except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
b. Test electrically operated units to verify that screen controls, limit switches, closures, and other operating components are in optimum functioning condition.
c. Test manually operated units to verify that screen-operating components are in optimum functioning condition.

B. Rigid Rear-Projection Screen Installation
1. Install rear-projection screens at locations indicated to comply with screen manufacturer's written instructions. Handle screens carefully during installation using procedures and tools recommended by screen manufacturer; do not abrade screen surfaces.
2. Install optically coated rear-projection screens with optical coating toward projector **OR** audience, **as directed**.
3. Install high-performance, rear-projection screens with orientation as indicated in manufacturer's written instructions.
4. Install factory-framed, rear-projection screens in prepared wall openings. Securely anchor frames to surrounding construction so frames are plumb and level and screen surfaces are flat.
5. Install rear-projection screens with glass substrates, in frames specified in other Sections, to comply with applicable requirements in Division 08 Section "Glazing" and with screen manufacturer's written instructions. Set projection screen with surfaces flat and edges plumb and level.

6. Install rear-projection screens with plastic substrates, in frames specified in other Sections, to comply with screen manufacturer's written instructions. Clamp units only at top edge and allow for expansion and contraction of plastic glazing material by providing frame with adequate bite and edge clearances.

C. Protecting And Cleaning Rigid Rear-Projection Screens
1. Provide temporary covering of rear-projection screens until time of Substantial Completion. Use type of covering approved by screen manufacturer that will effectively protect screen from abrasion, breakage, or other damage.
2. Clean rear-projection screens on both faces immediately before date scheduled for inspection intended to establish date of Substantial Completion. Use methods and cleaning materials recommended by screen manufacturer, taking care not to scratch or damage optical coatings or screen substrates.

D. Projection Screen Schedule
1. Manually Operated, Front-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished, **as directed**.
   a. Screen Surface: Matte white **OR** Matte gray **OR** Glass beaded **OR** Matte reflective **OR** Wide-angle reflective **OR** Multipurpose reflective **OR** High-gain reflective, **as directed**.
   b. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
   c. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
2. Electrically Operated, Front-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished **OR** Suspended, without ceiling closure **OR** Suspended, with automatic ceiling closure, **as directed**.
   a. Motor Configuration: Motor in roller **OR** End-mounted motor on right end of screen **OR** End-mounted motor on left end of screen **OR** End-mounted motor on end of screen indicated, **as directed**.
   b. Screen Surface: Matte white **OR** Matte gray **OR** Glass beaded **OR** Matte reflective **OR** Wide-angle reflective **OR** Multipurpose reflective **OR** High-gain reflective, **as directed**.
   c. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
   d. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
3. Manually Operated, Rear-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished, **as directed**.
   a. Screen Type: Wide angle **OR** Moderate gain **OR** High gain, **as directed**.
   b. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
   c. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.
4. Electrically Operated, Rear-Projection Screen Type: Surface mounted, metal encased **OR** Surface mounted, wood finished **OR** Suspended, without ceiling closure **OR** Suspended, with automatic ceiling closure, **as directed**.
   a. Motor Configuration: Motor in roller **OR** End-mounted motor on right end of screen **OR** End-mounted motor on left end of screen **OR** End-mounted motor on end of screen indicated, **as directed**.
   b. Screen Type: Wide angle **OR** Moderate gain **OR** High gain, **as directed**.

c. Viewing Surface Size: 50 by 50 inches (1270 by 1270 mm) **OR** 60 by 60 inches (1524 by 1524 mm) **OR** 70 by 70 inches (1778 by 1778 mm) **OR** 84 by 84 inches (2133 by 2133 mm) **OR** 48 by 65 inches (1219 by 1651 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 58 by 79 inches (1473 by 2006 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.

d. Extra Drop Length: As needed at top of screen for bottom of screen to be 36 inches (900 mm) above floor and 36 inches (900 mm) at bottom of screen, **as directed**.

5. Rigid Rear-Projection Screen Type: Optically coated screen.
   a. Screen Substrate: Glass **OR** Acrylic, **as directed**.
   b. Screen Type: Wide angle **OR** Moderate gain **OR** General purpose **OR** High gain, **as directed**.
   c. Optical Tint: High-contrast dark gray **OR** Medium neutral gray **OR** Neutral white, **as directed**.
   d. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
   e. Additional Features: Protective coating **OR** Writing surface coating **OR** Factory frame, **as directed**.
6. Rigid Rear-Projection Screen Type: High-performance screen.
   a. Gain: Not less than 1.5 **OR** 3 **OR** 3.5 **OR** 4 **OR** 5, **as directed**.
   b. Horizontal Half-Gain Angle: At least 20 **OR** 25 **OR** 30 **OR** 50, **as directed**, degrees from screen axis.
   c. Size of Viewing Surface: 40 by 54 inches (1016 by 1371 mm) **OR** 43 by 57 inches (1092 by 1447 mm) **OR** 50 by 67 inches (1270 by 1701 mm) **OR** 54 by 72 inches (1371 by 1828 mm) **OR** 60 by 80 inches (1524 by 2032 mm) **OR** 72 by 96 inches (1828 by 2438 mm), **as directed**.
   d. Additional Features: Factory frame.

END OF SECTION 11132

Task	Specification	Specification Description
11132	01352	No Specification Required

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SECTION 11161 - LOADING DOCK EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for loading dock equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Dock levelers.
b. Truck levelers.
c. Truck restraints.
d. Light-communication systems.
e. Dock bumpers.
f. Dock lifts (scissors lifts).
g. Dock seals.
h. Dock shelters.
i. Transparent-strip door curtains.

C. Definitions
1. Operating Range: Maximum amount of travel above and below the loading dock level.
2. Working Range: Recommended amount of travel above and below the loading dock level for which loading and unloading operations can take place.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For loading dock equipment. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each type of dock-seal and -shelter fabric indicated.
4. Qualification Data: For qualified Installer.
5. Welding certificates.
6. Product Test Reports.
7. Operation and Maintenance Data.
8. Warranty: Sample of special warranty.

E. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Welding Qualifications: Qualify procedures and personnel according to the following:
a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. AWS D1.3, "Structural Welding Code - Sheet Steel."
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling
1. Store and handle dock seals and shelters in a manner to avoid significant or permanent damage to fabric or frame.

a. Comply with manufacturer's written instructions for minimum and maximum temperature requirements for storage.

G. Project Conditions
1. Field Measurements: Verify actual dimensions of construction contiguous with loading dock equipment, including recessed pit dimensions. slopes of driveways, and heights of loading docks, by field measurements before fabrication.

H. Warranty
1. Special Warranty for Dock Levelers: Manufacturer's standard form in which manufacturer agrees to repair or replace dock-leveler components that fail in materials or workmanship within specified warranty period.
a. Failures include, but are not limited to, the following:
1) Structural failures including cracked or broken structural support members, load-bearing welds, and front and rear hinges.
2) Faulty operation of operators, control system, or hardware.
3) Deck plate failures including cracked plate or permanent deformation in excess of 1/4 inch (6 mm) between deck supports.
4) Hydraulic system failures including failure of hydraulic seals and cylinders.
b. Warranty Period for Structural Assembly: 10 years from date of Substantial Completion.
c. Warranty Period for Hydraulic System: Five years from date of Substantial Completion.
d. Warranty shall be for unlimited usage of leveler for the specified rated capacity over the term of the warranty.

1.2 PRODUCTS

A. Materials
1. Steel Plates, Shapes, and Bars: ASTM 36/A 36M.
2. Rolled-Steel Floor Plate: ASTM A 786/A 786M, rolled from steel plate complying with ASTM A 572/A 572M, Grade 55 (380).
3. Steel Tubing: ASTM A 500, cold formed.
4. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
5. Wood: DOC PS 20 dimension lumber, select structural grade, kiln dried.
6. Pressure-Treated Wood: DOC PS 20 dimension lumber, select structural grade, kiln dried, and pressure treated with waterborne preservatives to comply with AWPA C2.

B. Recessed Dock Levelers
1. General: Recessed, hinged-lip-type dock levelers designed for permanent installation in concrete pits preformed in the edge of loading platform; of type, function, operation, capacity, size, and construction indicated; and complete with controls, safety devices, and accessories required.
2. Standard: Comply with MH 30.1, except for structural testing to establish rated capacity, **as directed**.
3. Rated Capacity: Capable of supporting total gross load without permanent deflection or distortion.
4. Platform: Not less than 3/16-inch- (5-mm-) **OR** 1/4-inch- (6-mm-) **OR** 3/8-inch- (9.5-mm-), **as directed**, thick, nonskid steel plate.
a. Platform Size: As indicated on Drawings, **as directed**.
b. Frame: Manufacturer's standard **OR** Clean-pit type, designed to support leveler at sides of pit, with no side-to-side supports at front of pit floor, **as directed**.
c. Toe Guards: Equip open sides of dock leveler over range indicated with metal toe guards.
1) Toe-Guard Range: Entire upper operating **OR** working, **as directed**, range.
5. Hinged Lip: Not less than 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, nonskid steel plate.

a. Hinge: Full width, piano-type hinge with heavy-wall hinge tube and greased fittings, **as directed**, with gussets on lip and ramp for support.
b. Safety Barrier Lip: Designed to protect material-handling equipment from an accidental fall from loading platform edge of the dock leveler when the leveler is not in use.

6. Function: Dock levelers shall compensate for differences in height between truck bed and loading platform.
   a. Vertical Travel: Operating range above platform level of sufficient height to enable lip to extend and clear truck bed before contact with the following minimum working range:
      1) Above Adjoining Platform: 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** As indicated on Drawings, **as directed**.
      2) Below Adjoining Platform: 12 inches (305 mm) **OR** 14 inches (356 mm) **OR** As indicated on Drawings, **as directed**.
   b. Automatic Vertical Compensation: Floating travel of ramp with lip extended and resting on truck bed shall compensate automatically for upward or downward movement of truck bed during loading and unloading.
   c. Automatic Lateral Compensation: Tilting of ramp with lip extended and resting on truck bed shall compensate automatically for canted truck beds of up to 4 inches (102 mm) over width of ramp.
   d. Lip Operation: Manufacturer's standard mechanism that automatically extends and supports hinged lip on ramp edge with lip resting on truck bed over dock leveler's working range, allows lip to yield under impact of incoming truck, and automatically retracts lip when truck departs.
      1) Length of Lip Extension: 16 inches (406 mm) **OR** 18 inches (457 mm) **OR** 20 inches (508 mm) **OR** As indicated on Drawings, **as directed**.
   e. Automatic Ramp Return: Automatic return of unloaded ramp, from raised or lowered positions to stored position, level with platform, as truck departs.
   f. Interlock: Leveler will not operate while overhead door is in closed position **OR** leveler night lock is engaged **OR** truck restraint is not engaged **OR** inflatable dock seal is not inflated **OR** inflatable dock shelter is not inflated, **as directed**.
7. Mechanical Operating System: Manual control; counterbalance and spring operation. Spring-operated raising and walk-down lowering of unloaded ramp. Equip leveler with an upward-biased-spring counterbalancing mechanism controlled by a hold-down device. Ramp raises to top limit of operating range by operating recessed control handle in ramp to disengage hold-down device. Ramp lowers below platform level with lip retracted by operating auxiliary, recessed control handle to release support legs.
   a. Free-Fall Protection: Manufacturer's standard protection system to limit free fall of loaded ramps with front edge supported by truck bed.
8. Hydraulic Operating System: Electric control from a remote-control station; fully hydraulic operation. Electric-powered hydraulic raising and hydraulic lowering of ramp. Equip leveler with a packaged unit including a unitized, totally enclosed, nonventilated electric motor, pump, manifold reservoir, and valve assembly of proper size, type, and operation for capacity of leveler indicated. Include means for lowering ramp below platform level with lip retracted behind dock bumpers. Provide a hydraulic velocity fuse connected to main hydraulic cylinder to limit loaded ramp's free fall to not more than 3 inches (76 mm).
   a. Remote-Control Station: Weatherproof single **OR** Single, **as directed**,-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 4 **OR** Type 12, **as directed**, box. Ramp raises by depressing and holding button; ramp lowers at a controlled rate by releasing button.
   b. Remote-Control Station with Emergency Stop: Weatherproof multibutton **OR** Multibutton, **as directed**, control station with an UP button of the constant-pressure type and an emergency STOP button of the momentary-contact type, enclosed in NEMA ICS 6, Type 4 **OR** Type 12, **as directed**, box. Ramp raises by depressing and holding UP button; ramp lowers at a controlled rate by releasing UP button. All ramp movement stops, regardless of position of ramp or lip, by depressing STOP button. Normal operation resumes by engaging a manual reset button or by pulling out STOP button.

1) Dual-Panel Control Station: Remote-control station for operating side-by-side dock levelers.
2) Master Panel: Control panel with integral fused disconnecting means for operating dock leveler, dock door, and truck restraints.

c. Independent Lip Operation: Electric-powered hydraulic raising and hydraulic lowering of lip, controlled independent of raising and lowering of ramp.

9. Electric Operating System: Electric control from a remote-control station; motorized operation. Electric activation for raising of ramp and automatic extending of lip. Equip leveler with a packaged unit including a unitized electric motor and shaft assembly of proper size, type, and operation for capacity of leveler indicated. Include means for lowering ramp below platform level with lip retracted behind dock bumpers.
   a. Remote-Control Station: Weatherproof single **OR** Single, **as directed**,-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 4 **OR** Type 12, **as directed**, box. Ramp raises by depressing and holding button; ramp lowers at a controlled rate by releasing button.
   b. Remote-Control Station with Emergency Stop: Weatherproof multibutton **OR** Multibutton, **as directed**, control station with an UP button of the constant-pressure type and an emergency STOP button of the momentary-contact type, enclosed in NEMA ICS 6, Type 4 **OR** Type 12, **as directed**, box. Ramp raises by depressing and holding UP button; ramp lowers at a controlled rate by releasing UP button. All ramp movement stops, regardless of position of ramp or lip, by depressing STOP button. Normal operation resumes by engaging a manual reset button or by pulling out STOP button.
10. Air-Bag Operating System: Electric control from a remote-control station; pneumatic operation. High-volume, low-pressure lifting of ramp. Equip leveler with a packaged unit including a PVC-coated, reinforced polyester lifting bag and two-stage, single-speed electric fan of proper size, type, and operation for capacity of leveler indicated. Include dock-leveler supports controlled by release chain for lowering ramp below platform level without extending lip.
   a. Remote-Control Station: Weatherproof single **OR** Single, **as directed**,-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 4, **as directed**, box. Ramp raises by depressing and holding button; ramp lowers at a controlled rate by releasing button.
11. Construction: Fabricate dock-leveler frame, platform supports, and lip supports from structural- or formed-steel shapes. Weld platform and hinged lip to supports. Fabricate entire assembly to withstand deformation during both operating and stored phases of service. Chamfer lip edge to minimize obstructing wheels of material-handling vehicles.
   a. Cross-Traffic Support: Manufacturer's standard method of supporting ramp at platform level in stored position with lip retracted. Provide a means to release supports to allow ramp to descend below platform level.
   b. Maintenance Strut: Integral strut to positively support ramp in up position during maintenance of dock leveler.
12. Integral Molded-Rubber Dock Bumpers: Fabricated from 4-inch- (102-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, heavy molded-rubber compound reinforced with nylon, rayon, or polyester cord; with Type A Shore durometer hardness of 80, plus or minus 5, when tested according to ASTM D 2240. Provide two dock bumpers for each recessed dock leveler, attached to face of loading dock with expansion bolts.
13. Integral Laminated-Tread Dock Bumper: Fabricated from 4-1/2-inch- (114-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles.
14. Accessories:
   a. Curb Angles: 3-by-3-by-1/4-inch (76-by-76-by-6-mm) galvanized-steel curb angles for edge of recessed leveler pit, with 1/2-inch- (13-mm-) diameter by 6-inch- (152-mm-) long concrete anchors welded to angle at 6 inches (152 mm) o.c.

b. Self-Forming Pan: Manufacturer's standard prefabricated, self-forming steel form system for poured-in-place construction of concrete pit.
c. Night Locks: Manufacturer's standard means to prevent extending lip and lowering ramp when overhead doors are locked.
d. Side and rear weatherseals.
e. Foam insulation under dock-leveler platform.
f. Abrasive skid-resistant **OR** Smooth, **as directed**, surface.

15. Finish: Paint **OR** Hot-dip galvanize, **as directed**, dock levelers after assembly and testing, **as directed**.
    a. Toe Guards: Paint yellow **OR** orange, **as directed**, to comply with ANSI Z535.1.

C. Edge-Of-Dock Levelers

1. General: Surface-mounted, hinged-lip-type, edge-of-dock levelers designed for permanent installation on face of loading dock platform; of type, function, operation, capacity, size, and construction indicated; and complete with controls, safety devices, and accessories required.
2. Standard: Comply with MH 30.1, except for structural testing to establish rated capacity, **as directed**.
3. Rated Capacity: Capable of supporting total gross load without permanent deflection or distortion.
4. Platform Ramp Width: 66 inches (1676 mm) **OR** 72 inches (1829 mm) **OR** 78 inches (1981 mm) **OR** 84 inches (2134 mm) **OR** As indicated on Drawings, **as directed**.
5. Hinged Lip: Not less than 3/8-inch- (9.5-mm-) **OR** 7/16-inch- (11-mm-) **OR** 1/2-inch- (13-mm-), **as directed**, thick, nonskid steel tread plate.
    a. Hinge: Full width, piano-type hinge with heavy-wall hinge tube and greased fittings, **as directed**, with gussets on lip and ramp for support.
6. Function: Dock levelers shall compensate for differences in height between truck bed and loading platform.
    a. Vertical Travel: Operating range above platform level of sufficient height to enable lip to extend and clear truck bed before contact with the following minimum working range:
        1) Above Adjoining Platform: 5 inches (127 mm) **OR** 6 inches (152 mm) **OR** As indicated on Drawings, **as directed**.
        2) Below Adjoining Platform: 5 inches (127 mm) **OR** As indicated on Drawings, **as directed**.
    b. Automatic Vertical Compensation: Floating travel of ramp with lip extended and resting on truck bed shall compensate automatically for upward or downward movement of truck bed during loading and unloading.
    c. Automatic Lateral Compensation: Tilting of ramp with lip extended and resting on truck bed shall compensate automatically for canted truck beds of up to 3 inches (76 mm) over width of ramp.
    d. Lip Operation: Manufacturer's standard mechanism that automatically extends and supports hinged lip on ramp edge with lip resting on truck bed over dock leveler's working range, allows lip to yield under impact of incoming truck, and automatically retracts lip when truck departs.
        1) Length of Lip Extension: 15 inches (381 mm) **OR** 17 inches (432 mm) **OR** As indicated on Drawings, **as directed**.
    e. Automatic Ramp Return: Automatic return of unloaded ramp, from raised or lowered positions to stored position, level with platform, as truck departs. Leveler shall be capable of retracting to stored position while truck is at loading dock.
7. Mechanical Operating System: Manual control; counterbalance and spring operation. Spring-operated raising and walk-down lowering of unloaded ramp. Equip leveler with a torsion-spring counterbalancing mechanism controlled by a hold-down device.
    a. Lever Handle: Self-storing lever handle for raising unloaded ramp with minimal lifting force by pulling lever back to extend lip and pushing lever forward to lower ramp and lip.
    b. Removable Lifting Handle: For raising unloaded ramp by lifting action.
8. Hydraulic Operating System: Electric control from a remote-control station; fully hydraulic operation. Electric-powered hydraulic raising and hydraulic lowering of ramp. Equip leveler with

a packaged unit including a unitized, totally enclosed, nonventilated electric motor, pump, manifold reservoir, and valve assembly of proper size, type, and operation for capacity of leveler indicated. Provide a hydraulic velocity fuse connected to main hydraulic cylinder to limit loaded ramp's free fall to not more than 3 inches (76 mm).

a. Remote-Control Station: Weatherproof single **OR** Single, **as directed**,-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 12, **as directed**, box. Ramp and lip raise to vertical position and extend to truck bed by depressing and holding button.

9. Construction: Fabricate dock-leveler frame, platform supports, and lip supports from structural- and formed-steel shapes. Weld platform and hinged lip to supports. Fabricate entire assembly to withstand deformation during both operating and stored phases of service. Chamfer lip edge to minimize obstructing wheels of material-handling vehicles.
   a. Cross-Traffic Support: Manufacturer's standard method of supporting ramp at platform level in stored position with lip retracted. Provide a means to release supports to allow ramp to descend below platform level.
   b. Maintenance Strut: Integral strut to positively support ramp in up position during maintenance of dock leveler.
10. Integral Molded-Rubber Dock Bumpers: Fabricated from 4-inch- (102-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, heavy molded-rubber compound reinforced with nylon, rayon, or polyester cord; with Type A Shore durometer hardness of 80, plus or minus 5, when tested according to ASTM D 2240. Provide two dock bumpers for each recessed dock leveler, attached to face of loading dock with expansion bolts.
11. Integral Laminated-Tread Dock Bumper: Fabricated from 4-1/2-inch- (114-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles.
12. Accessories:
   a. Self-forming pan.
   b. Cast-in-place design.
   c. Run-off guards.
   d. Ramp approach plate.
13. Dock-Leveler Finish: Painted in manufacturer's standard color.

D. Top-Of-Dock Levelers

E. General: Surface-mounted, hinged-lip-type, top-of-dock levelers designed for permanent installation on top edge of loading dock platform without concrete pit; of type, function, operation, capacity, size, and construction indicated; and complete with controls, safety devices, and accessories required.
1. Standard: Comply with MH 30.1, except for structural testing to establish rated capacity, **as directed**.
2. Rated Capacity: Capable of supporting total gross load without permanent deflection or distortion.
3. Platform Width: 72 inches (1829 mm) **OR** As indicated on Drawings, **as directed**.
4. Hinged Lip: Not less than 3/8-inch- (9.5-mm-) **OR** 7/16-inch- (11-mm-), **as directed**, thick, nonskid steel plate.
   a. Hinge: Full width, piano-type hinge with heavy-wall hinge tube and greased fittings, **as directed**, with gussets on lip and ramp for support.
5. Function: Dock levelers shall compensate for differences in height between truck bed and loading platform.
   a. Vertical Travel: Operating range above platform level of sufficient height to enable lip to extend and clear truck bed before contact with a minimum working range of 10 inches (250 mm), **as directed**, above and 4 inches (102 mm), **as directed**, below adjoining platform level.

b. Automatic Vertical Compensation: Floating travel of ramp with lip extended and resting on truck bed shall compensate automatically for upward or downward movement of truck bed during loading and unloading.

c. Lip Operation: Manufacturer's standard mechanism that automatically extends and supports hinged lip on ramp edge with lip resting on truck bed over dock leveler's working range, allows lip to yield under impact of incoming truck, and automatically retracts lip when truck departs.

1) Length of Lip Extension: 15 inches (381 mm) **OR** As indicated on Drawings, **as directed**.

d. Automatic Ramp Return: Automatic return of unloaded ramp, from raised or lowered positions to stored position, level with platform, as truck departs. Leveler shall be capable of retracting to stored position while truck is at loading dock.

6. Mechanical Operating System: Manual control; counterbalance and spring operation. Spring-operated raising and walk-down lowering of unloaded ramp. Equip leveler with a torsion-spring counterbalancing mechanism controlled by a hold-down device.

a. Removable Lifting Hook: For raising unloaded ramp by lifting action and pushing forward to lower ramp and lip.

7. Hydraulic Operating System: Electric control from a remote-control station, fully hydraulic operation. Electric-powered hydraulic raising and hydraulic lowering of ramp. Equip leveler with a packaged unit including a unitized, totally enclosed, nonventilated electric motor, pump, manifold reservoir, and valve assembly of proper size, type, and operation for capacity of leveler indicated.

a. Remote-Control Station: Weatherproof single **OR** Single, **as directed**,-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 12, **as directed**, box. Ramp and lip raise to vertical position and extend to truck bed by depressing and holding button.

8. Construction: Fabricate dock-leveler frame, platform supports, and lip supports from structural- or formed-steel shapes. Weld platform and hinged lip to supports. Fabricate entire assembly to withstand deformation during both operating and stored phases of service. Chamfer lip edge to minimize obstructing wheels of material-handling vehicles.

9. Integral Molded-Rubber Dock Bumpers: Fabricated from 4-inch- (102-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, heavy molded-rubber compound reinforced with nylon, rayon, or polyester cord; with Type A Shore durometer hardness of 80, plus or minus 5, when tested according to ASTM D 2240. Provide two dock bumpers for each recessed dock leveler, attached to face of loading dock with expansion bolts.

10. Integral Laminated-Tread Dock Bumper: Fabricated from 4-1/2-inch- (114-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles.

11. Dock-Leveler Finish: Painted in manufacturer's standard color.

F. Vertical-Storing Dock Levelers

1. General: Recessed, hinged-lip-type, vertical-storing dock levelers designed for permanent installation in shallow concrete pits preformed in the edge of loading platform; of type, function, operation, capacity, size, and construction indicated; and complete with controls, safety devices, and accessories required.

2. Standard: Comply with MH 30.1, except for structural testing to establish rated capacity, **as directed**.

3. Rated Capacity: Capable of supporting total gross load without permanent deflection or distortion.

4. Platform: Not less than 3/16-inch- (5-mm-) **OR** 1/4-inch- (6-mm-), **as directed**, thick, nonskid steel plate.

a. Platform Size: As indicated on Drawings, **as directed**.

5. Hinged Lip: Not less than 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-), **as directed**, thick, nonskid steel plate.

a. Hinge: Full width, piano-type hinge with heavy-wall hinge tube and greased fittings, **as directed**, with gussets on lip and ramp for support.

6. Function: Dock levelers shall compensate for differences in height between truck bed and loading platform.
   a. Vertical Travel: Operating range above platform level of sufficient height to enable lip to extend and clear truck bed before contact with the following minimum working range:
      1) Above Adjoining Platform: 6 inches (152 mm) **OR** 10 inches (250 mm) **OR** 12 inches (305 mm) **OR** As indicated on Drawings, **as directed**.
      2) Below Adjoining Platform: 6 inches (152 mm) **OR** As indicated on Drawings, **as directed**.
   b. Automatic Vertical Compensation: Floating travel of ramp with lip extended and resting on truck bed shall compensate automatically for upward or downward movement of truck bed during loading and unloading.
   c. Automatic Lateral Compensation: Tilting of ramp with lip extended and resting on truck bed shall compensate automatically for canted truck beds of up to 4 inches (102 mm) over width of ramp.
   d. Lip Operation: Manufacturer's standard mechanism that automatically extends and supports hinged lip on ramp edge with lip resting on truck bed over dock leveler's working range, allows lip to yield under impact of incoming truck, and automatically retracts lip when truck departs.
      1) Length of Lip Extension: 16 inches (406 mm) **OR** 18 inches (457 mm) **OR** 20 inches (508 mm) **OR** As indicated on Drawings, **as directed**.
7. Hydraulic Operating System: Electric control from a remote-control station; fully hydraulic operation. Electric-powered hydraulic raising and hydraulic lowering of ramp. Equip leveler with a packaged unit including a unitized, totally enclosed, nonventilated electric motor, pump, manifold reservoir, and valve assembly of proper size, type, and operation for capacity of leveler indicated. Provide a hydraulic velocity fuse connected to main hydraulic cylinder to limit loaded ramp's free fall to not more than 3 inches (76 mm). Provide mechanical lock that prevents leveler from lowering without hydraulic pressure.
   a. Remote-Control Station: Weatherproof single **OR** Single, **as directed**,-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 12, **as directed**, box. Ramp lowers at a controlled rate.
   b. Remote-Control Station with Emergency Stop: Weatherproof multibutton **OR** Multibutton, **as directed**, control station with an UP button of the constant-pressure type and an emergency STOP button of the momentary-contact type, enclosed in NEMA ICS 6, Type 12, **as directed**, box. Ramp raises by depressing and holding UP button; ramp lowers at a controlled rate by releasing UP button. All ramp movement stops, regardless of position of ramp or lip, by depressing STOP button. Normal operation resumes by engaging a manual reset button or by pulling out STOP button.
      1) Master Panel: Control panel with integral fused disconnecting means for operating dock leveler, dock door, and truck restraints.
   c. Independent Lip Operation: Electric-powered hydraulic raising and lowering of lip, controlled independent of raising and lowering of ramp.
8. Construction: Fabricate dock-leveler frame, platform supports, run-off guards, **as directed,** and lip supports from structural- or formed-steel shapes. Weld platform and hinged lip to supports. Fabricate entire assembly to withstand deformation during both operating and stored phases of service. Chamfer lip edge to minimize obstructing wheels of material-handling vehicles.
9. Integral Molded-Rubber Dock Bumpers: Fabricated from 4-inch- (102-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, heavy molded-rubber compound reinforced with nylon, rayon, or polyester cord; with Type A Shore durometer hardness of 80, plus or minus 5, when tested according to ASTM D 2240. Provide two dock bumpers for each recessed dock leveler, attached to face of loading dock with expansion bolts.
10. Integral Laminated-Tread Dock Bumper: Fabricated from 4-1/2-inch- (114-mm-) **OR** 6-inch- (152-mm-), **as directed**, thick, multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting

rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles.

11. Accessories:
    a. Interlock: Leveler will not operate while overhead door is in closed position **OR** truck restraint is not engaged, **as directed**.
    b. Curb Angles: 3-by-3-by-1/4-inch (76-by-76-by-6-mm) galvanized-steel curb angles for edge of recessed leveler pit, with 1/2-inch- (13-mm-) diameter by 6-inch- (152-mm-) long concrete anchors welded to angle at 6 inches (152 mm) o.c.
12. Finish: Paint **OR** Hot-dip galvanize, **as directed**, dock levelers after assembly and testing, **as directed**.

G. Truck Levelers
1. General: Two-cylinder, hydraulic ramp designed to raise and lower end of truck at loading dock. Equip leveler with a packaged unit including a unitized electric motor, pump, manifold reservoir, and valve assembly of proper size, type, and operation for capacity indicated. Provide manufacturer's standard means for limiting loaded ramp's free fall.
2. Rated Capacity: Capable of supporting total gross load without permanent deflection or distortion.
3. Travel Speed: Leveler raises and lowers at 3 fpm (0.015 m/s), measured at traveling end.
4. Surface-Mounted Units: Designed for mounting on surface of concrete driveway.
5. Shallow-Pit-Mounted Units: Designed for mounting in sloping shallow pit; capable of 18 inches (457 mm) of vertical travel above and below level of driveway.
6. Full-Pit-Mounted Units: Designed for installation in a fully recessed pit, with top of platform in stored position flush with driveway.
    a. Provide removable plate for access to pit for service.
7. Hydraulic Operating System: Electric control from a remote-control station; fully hydraulic operation. Self-contained, electric-powered hydraulic raising and hydraulic lowering of lift.
    a. Remote-Control Station: Weatherproof, multibutton control station of the constant-pressure type with UP and DOWN push buttons. Controller shall consist of magnetic motor starter with three-pole adjustable overloads and 24-V control transformer with 4-A, fused secondary prewired to terminal strips and enclosed in NEMA ICS 6, Type 12, **as directed**, box.
        1) Upper-Travel-Limit Switch: Equip unit with manufacturer's standard, adjustable, upper-travel-limit switch.
8. Construction: Fabricate truck leveler from structural- and formed-steel shapes; fabricate platform from nonskid steel plate. Construct platform with notch at loading-dock end to provide clearance for truck restraint.
    a. Cylinders: Equip truck leveler with not less than two heavy-duty, high-pressure, hydraulic, ram-type cylinders. Rams shall be manufacturer's standard, either direct-displacement plunger or rod-and-piston type with positive internal stops. Cylinder rods shall be chrome plated and polished.
9. Truck-Leveler Finish: Manufacturer's standard finish.

H. Truck Restraints
1. General: Manufacturer's standard device designed to engage truck's rear-impact guard and hold truck at loading dock. Restraint shall consist of an iron or steel restraining arm that raises until contacting rear-impact guard. Arm shall move vertically, automatically adjusting to varying height of truck due to loading and unloading operations.
2. Standard: Comply with MH 30.3.
3. Rated Capacity: Capable of supporting total gross load of <**Insert capacity**> without permanent deflection or distortion.
4. Operating Range: Capable of restraining rear-impact guards within a range from:
    a. Vertical: 12 inches (305 mm) **OR** 30 inches (762 mm) **OR** As indicated on Drawings, **as directed**, above driveway.

b. Horizontal: 12 inches (305 mm) **OR** As indicated on Drawings, **as directed**, in front of dock bumpers.

5. Power Operating System: Manufacturer's standard electromechanical or hydraulic unit.
   a. Remote-Control Station: Single-button station of the constant-pressure type, enclosed in NEMA ICS 6, Type 12, **as directed**, box. Restraint is engaged by depressing and holding button; restraint is released by releasing button.
   b. Interlock: Leveler will not operate while truck restraint is not engaged.
6. Mechanical Operating System: Restraint operates by use of a lifting rod or hook to raise engagement device.
7. Rear-Impact-Guard Sensor: Detects presence of rear-impact guard and automatically returns to stored position if rear-impact guard is not engaged, **as directed**.
8. Caution Signs: Exterior, surface mounted; designed to inform both dock attendant and truck driver; with sign copy as follows. Provide one sign at each truck-restraint location.
   a. Sign Copy in Forward and Reverse Text: Manufacturer's standard text permitting truck movement with green light, **as directed**.
   b. Interior Sign Copy: Manufacturer's standard text permitting truck movement with green light, **as directed**.
9. Light-Communication System: Red and green illuminated signal-light sets, with lens approximately 4 inches (102 mm) in diameter, designed to indicate status to both dock attendant and truck driver. Equip system with steel control panel located at interior of dock that includes illuminated lights indicating **OR** indicates, **as directed**, status of exterior signal lights. Provide signal-light set and control panel at each location indicated for light-communication system. Enclose exterior signal-light sets in steel or plastic housing with sunshade.
   a. Manual Operation: System is activated by push button or switch located on interior **OR** truck-restraint, **as directed**, control panel.
   b. Automatic Operation: System is activated automatically by limit switch **OR** photoelectric sensor **OR** magnetic switch, **as directed**, mounted on overhead door track. Provide on-off switch located on light-communication system **OR** truck-restraint, **as directed**, control panel.
   c. Automatic Operation: System is activated automatically when device engages rear-impact guard. Provide on-off switch located on truck-restraint control panel.
   d. Mounting: Wall **OR** Driveway **OR** Pit, **as directed**.
10. Alarm: Audible **OR** Visual **OR** Audible and visual, **as directed**, system indicating that rear-impact guard is not engaged, with manual reset.
11. Accessories: Interlock to dock leveler **OR** Key switch, **as directed**.
12. Truck-Restraint Finish: Painted **OR** Hot-dip galvanized, **as directed**.

I. Light-Communication Systems
   1. General: Provide communication system consisting of signal-light sets, caution signs, alarms, and controls for each location indicated.
   2. Caution Signs: Surface mounted; designed to inform both dock attendant and truck driver; with sign copy as follows:
      a. Exterior Sign Copy in Forward and Reverse Text: Manufacturer's standard text permitting truck movement with green light, **as directed**.
      b. Interior Sign Copy: Manufacturer's standard text permitting truck movement with green light, **as directed**.
   3. Signal-Light Sets: Red and green illuminated signal-light sets, with lens approximately 4 inches (102 mm) in diameter, designed to indicate status to both dock attendant and truck driver. Equip system with steel control panel that includes illuminated lights indicating **OR** indicates, **as directed**, status of exterior signal lights; located at interior of dock. Provide signal-light set and control panel at each location indicated for light-communication system. Enclose signal lights in steel or plastic housing, with exterior signal-light sets equipped with sunshade.
      a. Manual Operation: Lights are activated by push button or switch located on interior signal-light enclosure **OR** control panel, **as directed**.

b. Automatic Operation: Lights are activated automatically by limit switch **OR** photoelectric sensor **OR** magnetic switch, **as directed**, mounted on overhead door track. Provide on-off switch located on control panel.

J. Dock Bumpers

1. Laminated-Tread Dock Bumper: Fabricated from multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles.
   a. Thickness: 4-1/2 inches (114 mm) **OR** 6 inches (152 mm) **OR** As indicated on Drawings, **as directed**.
   b. Horizontal Style: 6 inches (152 mm) **OR** 10 inches (250 mm) **OR** 12 inches (305 mm), **as directed**, high by length indicated on Drawings, **as directed**.
   c. Vertical Style: 8 inches (203 mm) wide by 20 inches (508 mm) high **OR** 24 inches (610 mm) high **OR** 36 inches (914 mm) high **OR** height indicated on Drawings, as directed.
2. Molded-Rubber Bumpers: Fabricated from molded-rubber compound reinforced with nylon, rayon, or polyester cord; with Type A Shore durometer hardness of 80, plus or minus 5, when tested according to ASTM D 2240; of size and configuration indicated. Fabricate units with not less than two predrilled anchor holes.
   a. Configuration: T shape **OR** Inverted-L shape **OR** Square **OR** Rectangular **OR** As indicated on Drawings, **as directed**.
   b. Thickness: 2 inches (50 mm) **OR** 3 inches (76 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** As indicated on Drawings, **as directed**.
3. Extruded-Rubber Bumpers: Fabricated from ASTM D 2000, extruded synthetic rubber with Type A Shore durometer hardness of 75, plus or minus 5, when tested according to ASTM D 2240; of size and configuration indicated. Furnish units with predrilled anchor holes and concealed, flat, steel mounting bar.
   a. Configuration: Flat or ribbed, with 2-inch (50-mm) nominal thickness and 9-inch (229-mm) height **OR** 4-1/2-inch- (114-mm-) wide base and 4-inch (102-mm) depth with half-oval shape that compresses and returns to original shape **OR** As indicated on Drawings, **as directed**.
4. Steel-Face, Laminated-Tread Bumpers: Fabricated from multiple, uniformly thick plies cut from fabric-reinforced rubber tires and with 3/8-inch (9.5-mm) steel face plate of same size as rubber surface. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles. Weld face plate to two steel support brackets, which shall extend back to and engage 3/4-inch- (19-mm-) diameter support rods in elongated holes, allowing steel face to float on impact.
   a. Thickness: 4-1/2 inches (114 mm) **OR** 6 inches (152 mm) **OR** As indicated on Drawings, **as directed**.
   b. Horizontal Style: 6 inches (152 mm) **OR** 10 inches (250 mm) **OR** 12 inches (305 mm), **as directed**, high by length indicated, **as directed**.
   c. Vertical Style: 8 inches (203 mm) wide by 20 inches (508 mm) high **OR** 24 inches (610 mm) high **OR** 36 inches (914 mm) high **OR** height indicated, **as directed**.
5. Anchorage Devices: Hot-dip galvanized-steel anchor bolts, nuts, washers, bolts, sleeves, cast-in-place plates, and other anchorage devices as required to fasten bumpers securely in place and to suit installation type indicated.

K. Dock Lifts

1. General: Built-in, scissors-type, single-leg, hydraulic dock lift of capacity, size, and construction indicated; complete with controls, safety devices, and accessories required.
2. Standard: MH 29.1.

3. Rated Capacity: Lifting capacity of not less than 8000 lb (3629 kg) with 6500-lb (2948-kg) **OR** indicated on Drawings, **as directed**, axle load at ends and 5000-lb (2268-kg) **OR** indicated on Drawings, **as directed**, axle load at sides.
4. Platform: Nonskid, safety-tread **OR** Smooth-surface, **as directed**, heavy steel deck plate.
   a. Platform Size: As indicated on Drawings, **as directed**.
   b. Platform Guarding: Bevel toe guards **OR** Toe sensor **OR** Indicator bar **OR** Skirts **OR** Enclosure, **as directed**, to comply with requirements in MH 29.1.
   c. Removable **OR** Fixed, **as directed**, Handrails: Equip lift with handrails on two sides of platform with a single, removable chain across each end. Provide handrails not less than 39 inches (991 mm) high with midrail and 4-inch- (102-mm-) high kick plate at bottom. Mount rail sockets flush with platform surface, **as directed**.
5. Bridge: Nonskid, safety-tread steel **OR** High-tensile aluminum, **as directed**, plate.
   a. Hinged Bridge: Hinged, throw-over bridge bolted to full-length, heavy-duty, piano-type hinge welded to toe guard at end of platform. Provide bridge complete with heavy-duty lifting chains. Chamfer edge of bridge to minimize obstructing wheels of material-handling vehicles.
   b. Size: 18 inches (457 mm) long by 60 inches (1524 mm) wide **OR** 18 inches (457 mm) long by 72 inches (1829 mm) wide **OR** As indicated on Drawings, **as directed**.
   c. Locations: Ends **OR** Sides **OR** As indicated on Drawings, **as directed**.
6. Function: Dock lifts shall compensate for differences in height between truck bed and loading platform.
   a. Vertical Travel: Maximum of 60 inches (1524 mm), **as directed**, from a lowered height of 12 inches (305 mm), **as directed**, for a total raised height of 72 inches (1829 mm), **as directed**.
   b. Travel Speed: Nominal raising speed of 8 fpm (0.04 m/s) **OR** 10 fpm (0.05 m/s) **OR** 12 fpm (0.06 m/s), **as directed**.
   c. Vertical Travel and Travel Speed: As indicated on Drawings, **as directed**.
   d. Hinged Throw-Over Bridges Operation: Manual **OR** Manual-assist bridge winch **OR** Automatic powered, **as directed**.
7. Hydraulic Operating System: Self-contained, electric, hydraulic power unit for raising and lowering lift; of size, type, and operation needed for capacity of lift indicated; controlled from a remotely located push-button station.
   a. Power Unit: Consisting of continuous-duty motor, high-pressure gear pump, valve manifold, oil-line filters, and oil reservoir.
      1) Equip manifold with relief valve, check valve, pressure-compensated flow-control valve, and solenoid valve and with provisions for lowering lift manually if power fails.
      2) Equip reservoir, valve manifold, and pressure line with oil-line filters.
   b. Cylinders: Equip lift with not less than two heavy-duty, high-pressure, hydraulic, ram-type cylinders. Rams shall be manufacturer's standard, either direct-displacement plunger or rod-and-piston type with positive internal stops. Cylinder rods shall be chrome plated and polished.
      1) Rate of Descent Protection: Pressure-compensated flow control or hydraulic velocity fuse to limit down speed for each cylinder.
   c. Remote-Control Station: Multibutton control station of the constant-pressure type with UP and DOWN push buttons. Controller shall consist of magnetic motor starter with three-pole adjustable overloads and 24-V control transformer with 4-A, fused secondary prewired to terminal strips and enclosed in NEMA ICS 6, Type 12, **as directed**, box.
      1) Upper-Travel-Limit Switch: Equip unit with manufacturer's standard, adjustable, upper-travel-limit switch.
8. Construction: Fabricate lift from structural-steel shapes rigidly welded and reinforced for maximum strength, safety, and stability. Design assembly to withstand deformation during both operating and stored phases of service. Provide mounting brackets and removable lifting eyes for ease of installation.
   a. Scissors Mechanism: Fabricate leg members from heavy, steel-formed tube or plate members to provide maximum strength and rigidity.

b. Scissors Configuration: Single leg **OR** Multiple width **OR** Multiple length, **as directed**.
c. Bearings: Pivot points with permanently lubricated antifriction bushings or sealed ball-bearings for minimum maintenance.
d. Maintenance Leg: Removable, safety maintenance leg or hinged, safety maintenance bars.
e. Mounting: Surface **OR** Pit, **as directed**.

9. Dock Lift Finish: Painted **OR** Hot-dip galvanized, **as directed**.
   a. Toe Guards: Paint yellow **OR** orange, **as directed**, to comply with ANSI Z535.1.

L. Foam-Pad Dock Seals
1. General: Dock seals consisting of fabric-covered foam pads designed to compress 4 to 5 inches (102 to 127 mm) under pressure of truck body to form an airtight seal at jambs and head of loading dock openings; of type, size, and construction indicated.
2. Door Opening Size: As indicated on Drawings, **as directed**.
3. Stationary Head Pad: 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm), **as directed**, high and same depth as jamb pads; beveled, **as directed**; sized for opening width.
4. Adjustable Head Pad: 18 inches (457 mm) **OR** 24 inches (610 mm) **OR** 30 inches (762 mm), **as directed**, high and same depth as jamb pads; sized for opening width; with manufacturer's standard hardware and tension spring or counterweight mechanism for adjusting height of pad.
5. Jamb Pads: Square **OR** Beveled; tapered to reduce opening width, **as directed**.
   a. Nominal Size: 12 inches (305 mm) **OR** As indicated on Drawings, **as directed**, wide and sized for opening height.
6. Construction: Consisting of single- or double-ply, coated, fabric-covered, urethane-foam core with supporting frame. Fabricate jamb and head pads of same depth and sized for opening width.
   a. Pressure-Treated, **as directed**, Wood Support Frame: Factory painted; with steel mounting hardware.
   b. Steel Support Frame: Steel channel frame of manufacturer's standard weight, shape, and finish; with steel mounting hardware.
   c. Tapered Side Panels: Taper side panels to angle required to accommodate sloped loading dock approach grades and make sealing edge of dock shelter parallel to back edge of truck. Taper for declined **OR** inclined, **as directed**, approach.
   d. Cover Fabric: Vinyl-coated nylon or polyester with minimum total weight of 22 oz./sq. yd. (746 g/sq. m) **OR** 40 oz./sq. yd. (1356 g/sq. m), **as directed**.
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   e. Cover Fabric: Neoprene-coated nylon with minimum total weight of 16 oz./sq. yd. (543 g/sq. m) **OR** 40 oz./sq. yd. (1356 g/sq. m) **OR** 45 oz./sq. yd. (1526 g/sq. m), **as directed**.
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   f. Cover Fabric: Hypalon-coated nylon with minimum total weight of 16 oz./sq. yd. (543 g/sq. m) **OR** 40 oz./sq. yd. (1356 g/sq. m), **as directed**.
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   g. Cover Fabric: Manufacturer's proprietary cover fabric complying with the following minimum requirements:
      1) Tearing strength of not less than 300 by 300 lbf (1334 by 1334 N) when tested according to ASTM D 2261.
      2) Abrasion resistance of not less than 6000 cycles when tested according to FED-STD-191A-5306.
      3) Tensile strength of not less than 1200 by 1200 lbf (5338 by 5338 N) when tested according to FED-STD-191A-5100.

4) Cold resistance to minus 40 deg F (minus 40 deg C) when tested according to FED-STD-191A-5874.
5) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

h. Guide Strips: 4-inch- (102-mm-) wide, coated, nylon guide strips on jamb pads.

i. Pleated Protectors: On face of jamb pads of overlapping layers of coated fabric attached to base fabric; 4-inch (102-mm) **OR** 8-inch (203-mm) **OR** 16-inch (406-mm), **as directed**, wear exposure.

M. Inflatable Dock Seals

1. General: Inflatable dock seals consisting of one-piece jamb, sill, **as directed**, and header seals designed to inflate by motor/blower and compress against truck bodies to form airtight seals at loading dock openings; of type, size, and construction indicated.
2. Door Opening Size: As indicated on Drawings, **as directed**.
3. Head Members: One **OR** Two, **as directed**.
4. Jamb Members: One **OR** Two, **as directed**.
5. Construction: Fabricate header seal full width over jamb seals. Mount seals on pressure-treated wood frame with hot-dip galvanized-steel mounting hardware. Inflate seals by use of 1/2-hp motor/blower with on-off switch, mounted above header seal in galvanized-steel hood. Provide bottom of header and jamb seals with grommets to allow for release of moisture and excess air.

a. Fabric: Neoprene-coated nylon with minimum total weight of 14 oz./sq. yd. (475 g/sq. m).
1) Color: Black **OR** Gray **OR** Blue **OR** Brown **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

b. Fabric: Manufacturer's proprietary fabric complying with the following minimum requirements:
1) Tearing strength of not less than 110 by 85 lbf (489 by 378 N) when tested according to ASTM D 2261.
2) Abrasion resistance of not less than 490 cycles when tested according to FED-STD-191A-5306.
3) Tensile strength of not less than 500 by 440 lbf (2224 by 1957 N) when tested according to FED-STD-191A-5100.1.
4) Cold resistance to minus 40 deg F (minus 40 deg C) when tested according to FED-STD-191A-5874.
5) Color: Black **OR** Gray **OR** Blue **OR** Brown **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

N. Frame-Type Dock Shelters

1. General: Dock shelters designed to form a seal with sides and top of truck body while leaving entire width and height of truck's rear opening unobstructed; of type, size, and construction indicated.
2. Door Opening Size: As indicated on Drawings, **as directed**.
3. Rigid-Frame Type: Fabricated from translucent, fabric-covered **OR** fiberglass, **as directed**, side and top panels attached to fixed supporting framework. Provide head and side curtains with built-in flexible stays, wind straps between head curtain and side frame, pleated protectors on head curtain, and a yellow aim patch on side curtains. Slope head frame from center for drainage. Provide replaceable, fabric-covered, tapered, foam-bottom pads and protective steel bumpers of size and type required for application shown.
4. Flexible-Frame Type: Fabricated from fabric-covered side and top panels attached to retractable supporting framework with independent spring-tension extension arms. Provide head and side curtains with built-in flexible stays, pleated protectors on head curtain, and a yellow aim patch on side curtains. Provide replaceable, fabric-covered, tapered, foam-bottom pads of size and type required for application shown.

5. Head-Pad Height: 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 inches (610 mm) **OR** 30 inches (762 mm), **as directed**.
6. Construction: Fabricate framework, pads, bumpers, fabric for curtains and panels, and other components to sizes and shapes indicated or required to fit door opening sizes shown and allow for not less than 18 inches (457 mm) of truck-body penetration when truck is docked.
   a. Wood Framework: Factory painted, mechanically fastened together using nails and lag bolts or metal connectors to form a rigid assembly.
   b. Steel Framework: Zinc-plated steel tubing of size and thickness standard with manufacturer, with joints welded.
   c. Top and Side Panels: White, translucent fiberglass, 0.045 inch (1.1 mm) thick, weighing 6 oz./sq. ft. (1831 g/sq. m).
   d. Top and Side Panels: White, translucent vinyl, weighing 14 oz./sq. ft. (4272 g/sq. m).
   e. Tapered Side Panels: Taper side panels to angle required to accommodate sloped loading dock approach grades and make sealing edge of dock shelter parallel to back edge of truck. Taper for declined **OR** inclined, **as directed,** approach.
   f. Cover Fabric: Vinyl-coated nylon with minimum total weight of 22 oz./sq. yd. (746 g/sq. m) **OR** 40 oz./sq. yd. (1356 g/sq. m), **as directed**.
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   g. Cover Fabric: Polyurethane-coated nylon with minimum total weight of 25 oz./sq. yd. (848 g/sq. m).
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   h. Cover Fabric: Neoprene-coated nylon with minimum total weight of 16 oz./sq. yd. (543 g/sq. m) **OR** 40 oz./sq. yd. (1356 g/sq. m) **OR** 45 oz./sq. yd. (1526 g/sq. m), **as directed**.
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   i. Cover Fabric: Hypalon-coated nylon with minimum total weight of 16 oz./sq. yd. (543 g/sq. m) **OR** 40 oz./sq. yd. (1356 g/sq. m), **as directed**.
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   j. Cover Fabric: Manufacturer's proprietary cover fabric complying with the following minimum requirements:
      1) Tearing strength of not less than 300 by 300 lbf (1334 by 1334 N) when tested according to ASTM D 2261.
      2) Abrasion resistance of not less than 6000 cycles when tested according to FED-STD-191A-5306.
      3) Tensile strength of not less than 1200 by 1200 lbf (5338 by 5338 N) when tested according to FED-STD-191A-5100.1.
      4) Cold resistance to minus 40 deg F (minus 40 deg C) when tested according to FED-STD-191A-5874.
      5) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** Tan **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   k. Pleated Protectors: Overlapping layers of same fabric as cover.
7. Accessories:
   a. Buffer flaps.
   b. Bottom filler curtain.
   c. Bottom seal pads.

O. Inflatable Dock Shelters

1. General: Inflatable dock shelters designed to inflate by motor/blower and compress against truck bodies to form airtight seals at loading dock openings; of type, size, and construction indicated.
2. Door Opening Size: As indicated on Drawings, **as directed**.
3. Rigid Canopy: Consisting of rigid canopy, fabric-covered header curtain, and one-piece inflatable header and jamb seals. Fabricate canopy from white, translucent plastic attached to rigid support framework.
4. Rigid Canopy and Sides: Consisting of rigid canopy and sides, fabric-covered header curtain, and one-piece, inflatable header and jamb seals. Fabricate canopy and sides from white, translucent plastic attached to rigid support framework.
5. Construction: Fabricate header seal full width over jamb seals. Mount seals on pressure-treated wood frame with hot-dip galvanized-steel mounting hardware. Provide header curtain with built-in flexible stays and two yellow aim patches. Slope canopy frame from center for drainage. Provide two protective steel bumpers of size and type required for application shown. Inflate seals by use of a 1/2-hp motor/blower with on-off switch, mounted under canopy frame. Provide bottom of header and jamb seals with grommets to allow for release of moisture and excess air.
   a. Shape and Size: Fabricate framework, fabric for curtains, and other components to sizes and shapes indicated or required to fit door opening sizes shown and allow for not less than 12 inches (305 mm) of truck-body penetration when truck is docked.
   b. Wood Framework: Fasten members together mechanically using nails and lag bolts or metal connectors to form a rigid assembly.
   c. Steel Framework: Zinc-plated steel tubing of size and thickness standard with manufacturer, with joints welded.
   d. Fabric: Polyurethane **OR** Vinyl, **as directed**,-coated nylon with minimum total weight of 14 oz./sq. yd. (475 g/sq. m).
      1) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.
   e. Fabric: Manufacturer's proprietary fabric complying with the following minimum requirements:
      1) Tearing strength of not less than 110 by 85 lbf (489 by 378 N) when tested according to ASTM D 2261.
      2) Abrasion resistance of not less than 490 cycles when tested according to FED-STD-191A-5306.
      3) Tensile strength of not less than 500 by 440 lbf (2224 by 1957 N) when tested according to FED-STD-191A-5100.1.
      4) Cold resistance to minus 40 deg F (minus 40 deg C) when tested according to FED-STD-191A-5874.
      5) Color: Black **OR** Green **OR** Blue **OR** Brown **OR** As indicated by manufacturer's designations **OR** Match sample **OR** As selected from manufacturer's full range, **as directed**.

P. Transparent-Strip Door Curtains
1. General: Door curtains consisting of overlapping strips suspended from top of opening to form a sealed door curtain. Provide strips of length required to suit opening height and with sufficient number in unit to close opening width with overlap indicated.
2. Strip Material: Curved, clear, transparent, extruded PVC. Fabricate strips for manufacturer's standard method of attachment to overhead mounting system indicated.
   a. Standard Grade: Designed to withstand temperature range of 0 to plus 150 deg F (minus 18 to plus 66 deg C).
   b. Low-Temperature Grade: USDA accepted, designed to withstand temperature range of minus 30 to plus 150 deg F (minus 34 to plus 66 deg C).
   c. Strip Width and Thickness:
      1) 6 inches (152 mm) wide and 0.060 inch (1.5 mm) thick.
         OR
         8 inches (203 mm) wide and 0.080 inch (2 mm) thick.

OR
12 inches (305 mm) wide and 0.120 inch (3 mm) thick.
OR
16 inches (406 mm) wide and 0.160 inch (4 mm) thick.

d. Overlap: None **OR** One-third **OR** One-half **OR** Two-thirds **OR** Three-quarters **OR** Full, **as directed**.

3. Header Mounting: Consisting of an angle bolted or welded to opening lintel; equip angle with permanently attached mounting pins and a steel-angle or -plate retaining strip attached to angle with wing nuts.
4. Wall Surface Mounting:
   a. Consisting of a steel plate bolted to side of lintel; equip plate with permanently attached, threaded, mounting pins and steel-angle or -plate retaining strip attached to plate with wing nuts.
   OR
   Consisting of steel pipe attached to side of lintel by manufacturer's standard, winged-U-type suspension brackets.
   OR
   Consisting of a rigid, vinyl wall-mounting unit bolted to side of lintel above opening; equip unit with a similarly formed, rigid, vinyl retainer attached to unit with wing nuts.

Q. General Finish Requirements
1. Finish loading dock equipment after assembly and testing.

R. Steel Finishes
1. Galvanizing: Hot-dip galvanize components as indicated to comply with the following:
   a. ASTM A 123/A 123M for iron and steel loading dock equipment.
   b. ASTM A 153/A 153M or ASTM F 2329 for iron and steel hardware for loading dock equipment.
2. Galvanized-Steel and Steel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat in manufacturer's standard color.

1.3 EXECUTION

A. Preparation
1. Coordinate size and location of loading dock equipment indicated to be attached to or recessed into concrete or masonry, and furnish anchoring devices with templates, diagrams, and instructions for their installation.
2. Set curb angles in concrete edges of dock-leveler recessed pits with tops flush with loading platform. Fit exposed connections together to form hairline joints.
3. Set curb angles in concrete edges of truck-leveler recessed pits with tops flush with driveway. Fit exposed connections together to form hairline joints.
4. Place self-forming pan system for recessed dock **OR** edge-of-dock, **as directed**, levelers in proper relation to loading platform before pouring concrete.
5. Clean recessed pits of debris.

B. Installation
1. General: Install loading dock equipment, including motors, pumps, control stations, wiring, safety devices, light-communication systems, and accessories as required for a complete installation.
   a. Rough-in electrical connections according to requirements specified in Division 15..
2. Recessed Dock Levelers: Attach dock levelers securely to loading dock platform, flush with adjacent loading dock surfaces and square to recessed pit.
3. Edge **OR** Top, **as directed**,-of-Dock Levelers: Attach dock levelers to loading dock platform in a manner that complies with requirements indicated for arrangement and position relative to top of platform.

a. Weld anchor holes in contact with continuous embedded loading dock edge channel. Weld or bolt bumper blocks to face of loading dock.

4. Truck Levelers: Attach truck levelers securely to driveway construction with expansion anchors and bolts.
5. Truck Restraints: Attach truck restraints in a manner that complies with requirements for arrangement and height required for device to engage vehicle rear-impact guard. Interconnect control panel and signals with dock leveler, **as directed**.
   a. Wall-Mounted Units: Weld truck restraints to steel curb angle **OR** edge channel **OR** mounting plate, **as directed**, embedded in loading dock edge.
   b. Wall-Mounted Units: Anchor truck restraints to face of loading dock with expansion anchors and bolts.
   c. Driveway-Mounted Units: Anchor truck restraints to driveway with expansion anchors and bolts.
   d. Pit-Mounted Units: Anchor truck restraints to concrete pit with expansion anchors and bolts.
6. Dock Bumpers: Attach dock bumpers to face of loading dock in a manner that complies with requirements indicated for spacing, arrangement, and position relative to top of platform and anchorage.
   a. Welded Attachment: Plug-weld anchor holes in contact with steel inserts and fillet weld at other locations.
   b. Bolted Attachment: Attach dock bumpers to preset anchor bolts embedded in concrete or to cast-in-place inserts or threaded studs welded to embedded-steel plates or angles. If preset anchor bolts, cast-in-place inserts, or threaded studs welded to embedded-steel plates or angles are not provided, attach dock bumpers by drilling and anchoring with expansion anchors and bolts.
   c. Screw Attachment: Attach dock bumpers to wood construction with lag bolts as indicated.
7. Dock Lifts: Attach dock lifts securely to loading platform **OR** floor of recessed pit **OR** surface of driveway, **as directed**.
8. Dock Seals: Attach dock-seal support frames securely to building structure in proper relation to openings, dock bumpers, and dock levelers to ensure compression of dock seals when trucks are positioned against dock bumpers.
9. Dock Shelters: Attach dock shelters securely to building structure in proper relation to openings, dock bumpers, and dock levelers to ensure an effective seal of dock-shelter curtains with sides and top of truck body when trucks are positioned against dock bumpers.
10. Transparent-Strip Door Curtains: Attach door-curtain mounting system to lintel with screw anchors or toggle bolts. Mount curtain strips to achieve overlap indicated.

C. Adjusting
1. Adjust loading dock equipment to function smoothly and safely, and lubricate as recommended by manufacturer.
2. Test dock levelers and lifts for vertical travel within operating range indicated.
3. After completing installation of exposed, factory-finished loading dock equipment, inspect exposed finishes and repair damaged finishes.

END OF SECTION 11161

Task	Specification	Specification Description
11162	11161	Loading Dock Equipment
11163	11161	Loading Dock Equipment
11167	11161	Loading Dock Equipment
11168	11161	Loading Dock Equipment

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SECTION 11425 - FOOD SERVICE EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for food service equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fabricated equipment.
b. Food waste machines.
c. Cooking equipment.
d. Self-contained refrigeration equipment.
e. Walk-in refrigeration equipment.
f. Powered food-preparation equipment.
g. Warewashing equipment.
h. Serving equipment.
i. Utility distribution systems.
2. Owner-Furnished Equipment: Where indicated, Owner will furnish equipment for installation by Contractor.

C. Submittals
1. Product Data: For each type of product indicated. Include the following:
a. Manufacturer's model number.
b. Accessories and components that will be included for Project.
c. Clearance requirements for access and maintenance.
d. Utility service connections for water, drainage, power, and fuel; include roughing-in dimensions.
2. Shop Drawings: For fabricated equipment. Include plans, elevations, sections, roughing-in dimensions, fabrication details, utility service requirements, and attachments to other work.
3. Samples: For each factory-applied color finish required, in manufacturer's standard sizes.
4. Coordination Drawings: For foodservice facilities.
a. Indicate locations of foodservice equipment and connections to utilities.
b. Key equipment using same designations as indicated on Drawings.
c. Include plans and elevations; clearance requirements for equipment access and maintenance; details of equipment supports; and utility service characteristics.
d. Include details of seismic bracing for equipment.
5. Operation and Maintenance Data: For foodservice equipment to include in emergency, operation, and maintenance manuals. Include the following:
a. Product Schedule: For each foodservice equipment item, include the following:
1) Designation indicated on Drawings.
2) Manufacturer's name and model number.
3) List of factory-authorized service agencies including addresses and telephone numbers.
6. Warranty: Samples of special warranty.

D. Quality Assurance
1. NSF Standards: Provide equipment that bears NSF Certification Mark or UL Classification Mark certifying compliance with applicable NSF standards.
2. BISSC Standards: Provide bakery equipment that complies with BISSC/Z50.2.

a. Provide BISSC-certified equipment, with certification verified by a third-party agency, **as directed**.

3. UL Certification: Provide electric and fuel-burning equipment and components that are evaluated by UL for fire, electric shock, and casualty hazards according to applicable safety standards, and that are UL certified for compliance and labeled for intended use.
4. Steam Equipment: Provide steam-generating and direct-steam heating equipment that is fabricated and labeled to comply with ASME Boiler and Pressure Vessel Code.
5. Regulatory Requirements: Install equipment to comply with the following:
   a. ASHRAE 15, "Safety Code for Mechanical Refrigeration."
   b. NFPA 54, "National Fuel Gas Code."
   c. NFPA 70, "National Electrical Code."
   d. NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."
6. Seismic Restraints: Comply with SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines," Appendix A, "Seismic Restraint Details," unless otherwise indicated.
7. Preinstallation Conference: Conduct conference at Project site.

E. Project Conditions
1. Field Measurements: Verify actual dimensions of construction contiguous with foodservice equipment by field measurements before fabrication. Indicate measurements on Coordination Drawings.

F. Coordination
1. Coordinate foodservice equipment layout and installation with other work, including layout and installation of lighting fixtures, HVAC equipment, and fire-suppression system components.
2. Coordinate locations and requirements of utility service connections.
3. Coordinate sizes, locations, and requirements of the following:
   a. Overhead equipment supports.
   b. Equipment bases.
   c. Floor depressions.
   d. Insulated floors.
   e. Floor areas with positive slopes to drains.
   f. Floor sinks and drains serving foodservice equipment.
   g. Roof curbs, equipment supports, and penetrations.

G. Warranty
1. Refrigeration Compressor Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace compressors that fail in materials or workmanship within specified warranty period.
   a. Failure includes, but is not limited to, inability to maintain set temperature.
   b. Warranty Period: Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Fabricated Equipment
1. Stainless-Steel Sinks:
   a. Description: One **OR** Two **OR** Three **OR** Four, **as directed**,-compartment sink(s). Fabricate units of welded stainless steel, sound deadened.
      1) Bowls: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** 0.062 inch (1.59 mm), **as directed**, thick.
      2) Integral Drainboards: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** 0.062 inch (1.59 mm), **as directed**, thick.
      3) Body: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** Type 304, 0.062 inch (1.59 mm) **OR** Type 430, 0.062 inch (1.59 mm), **as directed**, thick.

a) Back Splash: Manufacturer's standard height **OR** 13 inches (330 mm) **OR** 18 inches (457 mm), **as directed**.
b) Side Splash: Manufacturer's standard height **OR** 13 inches (330 mm) **OR** 18 inches (457 mm), **as directed**.

4) Legs and Feet: Stainless-steel tubing legs with adjustable bullet feet.
5) Accessories:
a) Faucets and Spouts: as directed by the Owner.
b) Prerinse Faucet: as directed by the Owner.
c) Vacuum breaker.
d) Lever waste with **OR** without, **as directed**, overflow.
e) Basket strainer.
f) Continuous waste.
g) Scrap trough.
h) Control bracket for food waste disposer controls.
i) Scrap block and hole.
j) Stainless-steel pot rack.

b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
c. Fabrication: Prepare sink for installation of the following equipment items:
1) Water heater.
2) Food waste disposer; weld disposer cone or collar into sink.
3) Undercounter dishwasher.
d. Stainless-Steel Finish: Directional satin finish, No. 4.

2. Stainless-Steel Tables:
a. Description: Flat-countertop **OR** Prep **OR** Equipment-stand **OR** Mixer-stand **OR** Dish, **as directed**, table.
1) Tops: Stainless steel, Type 304, 0.078 inch (1.98 mm) **OR** Type 304, 0.062 inch (1.59 mm) **OR** Type 430, 0.062 inch (1.59 mm), **as directed**, thick, reinforced and sound deadened.
a) Back Splash: Manufacturer's standard height **OR** 1-1/2 inches (38 mm) **OR** 5 inches (127 mm), **as directed**.
b) Edge: Bullnose on four sides **OR** Bullnose on front edge, straight on sides and back **OR** Marine edge, **as directed**.
2) Welded **OR** Adjustable, **as directed**, Undershelf: Stainless steel, Type 304, 0.050 inch (1.27 mm) thick **OR** Metallic-coated steel, 0.052-inch (1.32-mm) nominal thickness, **as directed**.
3) Crossbracing: Stainless-steel **OR** Metallic-coated steel, **as directed**, tubing, bolted **OR** welded, **as directed**, to legs.
4) Cabinet:
a) Body: Stainless steel, Type 430, 0.050 inch (1.27 mm) thick.
b) Doors: Sliding **OR** Hinged, **as directed**, stainless steel, Type 304, 0.038 inch (0.95 mm) thick.
c) Drawers: Stainless-steel drawer and faceplate **OR** Galvanized-steel drawer and stainless-steel faceplate **OR** Stainless-steel front and liner **OR** Stainless-steel front and galvanized-steel liner, **as directed**.
5) Sink: Stainless steel, Type 304, 0.078 inch (1.98 mm) thick, welded into tabletop and including the following:
a) Faucet and Spout: as directed by the Owner.
b) Vacuum breaker.
c) Leverwaste with **OR** without, **as directed**, overflow.
d) Basket strainer.
e) Tail piece.
6) Legs: Stainless-steel **OR** Metallic-coated steel, **as directed**, tubing.
7) Feet: Stainless-steel adjustable bullets **OR** Plastic adjustable bullets **OR** Stainless-steel, flanged, adjustable bullets **OR** Casters, **as directed**.
8) Accessories:
a) Control panel.

b) Control bracket for food waste disposer controls.
c) Aluminum pan rack slides, six **OR** three, **as directed**, slides each.
d) Urn trough.
e) Spice bins.

b. Materials:
1) Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
2) Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B; with minimum G90 (Z275) coating.

c. Fabrication: Prepare table for installation of the following equipment items:
1) Food waste disposer; weld disposer cone or collar into sink.
2) Heat lamp.

d. Stainless-Steel Finish: Directional satin finish, No. 4.

3. Stainless-Steel Shelf Units:
a. Description: Table mounted, single deck **OR** Table mounted, double deck **OR** Wall mounted, **as directed**. Fabricate units of stainless steel, Type 304, 0.062 inch (1.59 mm) **OR** Type 304, 0.050 inch (1.27 mm) **OR** Type 430, 0.050 inch (1.27 mm), **as directed**, thick.
b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
c. Stainless-Steel Finish: Directional satin finish, No. 4.

4. Pot Racks:
a. Description: Wall mounted **OR** Ceiling hung **OR** Corner, **as directed**. Fabricate units of stainless steel **OR** painted, cold-rolled steel, **as directed**.
1) Bars: Double **OR** Single, **as directed**.
2) Hooks: 18 per unit.

b. Materials:
1) Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, Type 304.
2) Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, Commercial Steel (CS), Type B, suitable for exposed applications.

c. Finishes:
1) Stainless Steel: Directional satin finish, No. 4.
2) Cold-Rolled Steel: Powder-coat painted finish.

5. Stainless-Steel Hand Sinks:
a. Description: Lavatory sink. Fabricate units of stainless steel, Type 304, 0.050 inch (1.27 mm) **OR** 0.038 inch (0.95 mm), **as directed**, thick.
1) Operation: Electronic **OR** Knee valve **OR** Foot pedal **OR** Wrist handle **OR** Handle, **as directed**.
2) Faucet and Spout: as directed by the Owner.
3) Accessories:
a) Chrome-plated tail piece and P trap, NPS 1-1/2 (DN 40), with 0.045-inch (1.1-mm) minimum wall thickness.
b) Strainer basket with metal post.
c) Liquid soap dispenser, splash **OR** deck, **as directed**, mounted.
d) Liquid soap and towel dispenser.
e) Towel dispenser.
f) Tubular wall supports.
g) Skirt assembly for support.
h) Side splashes.

b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
c. Stainless-Steel Finish: Directional satin finish, No. 4.

6. Floor Troughs **OR** Water Receptacles, **as directed**:
a. Description: 4-inch (102-mm) **OR** 2-inch (50-mm), **as directed**, nominal depth excluding tailpiece.
1) Body: Stainless steel, Type 304, 0.078 inch (1.98 mm) thick.
2) Grate: Stainless-steel bar, Type 304 **OR** Fiberglass, **as directed**.

3) Waste Connection: NPS 3 (DN 80).

b. Materials:

1) Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.

2) Stainless-Steel Bars: ASTM A 276, austenitic stainless steel, type as indicated.

c. Stainless-Steel Finish: Directional satin finish, No. 4.

B. Food Waste Machines

1. Food Waste Disposer Units:

a. Description: 3 **OR** 5 **OR** 7, **as directed**, hp, with dual-direction shredding elements, and the following:

1) Stainless-steel **OR** Corrosion-resistant, **as directed**, housing.

2) Flow control.

3) Solenoid valve.

4) Vacuum breaker.

5) Fixed nozzle.

6) Control Panel:

a) Autoreversing and internal timed water flush.

b) Stainless-steel mounting bracket.

7) Prerinse: Backsplash mounted with hot- and cold-water mixing valve and with stainless-steel **OR** corrosion-resistant, **as directed**, exposed metal parts and the following:

a) Wall support bracket.

b) Flexible, 3/8-inch (10-mm) metal-encased hose with a minimum length of 29 inches (737 mm) and supported by spiral spring.

c) Spray-head assembly with lockable lever handle.

8) Accessories:

a) Collar adaptor for sink **OR** trough, **as directed**.

b) Cone with adaptor ring.

i. Size: 12 inches (305 mm) **OR** 15 inches (381 mm) **OR** 18 inches (457 mm), **as directed**.

c) Cone cover in size that matches cone.

d) Silver accumulator.

9) Electrical Service: Equip unit for connection to service indicated on Drawings.

2. Food Waste Pulper and Water Extractor Systems:

a. Description: Stainless-steel pulper unit, extractor unit, and control panel with water-level control and push-button start.

1) Capacity: Not less than 600 lb (272 kg) **OR** 700 lb (318 kg) **OR** 900 lb (408 kg), **as directed**, of waste per hour.

2) Accessories:

a) Feed trough connection.

b) Feed tray.

c) Feed hood assembly.

d) Under-dish-table lid.

e) Remote Water Extractor:

i. Dam, to prevent siphoning of water from pulper tank.

ii. Remote piping system, overhead **OR** below floor, **as directed**.

3) Electrical Service: Equip unit for connection to service indicated on Drawings.

3. Food Waste Grinder and Water Extractor Systems:

a. Description: Stainless-steel construction; with off and on controls on unit, food waste hopper, silver saver, internal disposer, removable water extraction auger with internal water sprays, and discharge chute.

1) Capacity: Not less than 600 lb (272 kg) **OR** 700 lb (318 kg), **as directed**, of waste per hour.

2) Accessories:

a) Reel rinse unit with spray valve.

b) Recirculation water pump.
c) Trough mount.
3) Electrical Service: Equip unit for connection to service indicated on Drawings.
4. Undercounter Food Waste Grinder and Water Extractors:
a. Description: Stainless-steel, undercounter, cleanable assembly including the following:
1) Capacity: Not less than 600 lb (272 kg) **OR** 700 lb (318 kg), **as directed**, of waste per hour.
2) Separate water-extractor and disposer units.
a) Disposer: Corrosion-resistant housing, dual-direction shredding elements.
3) Piping between disposer and water extractor.
4) Vacuum breaker.
5) Solenoid valve.
6) Flow control.
7) Time-delayed relay.
8) Control Panel:
a) Autoreversing and internal timed water flush.
b) Stainless-steel mounting bracket.
9) Prerinse: Backsplash mounted with hot- and cold-water mixing valve and with stainless-steel **OR** corrosion-resistant, **as directed**, exposed metal parts and the following:
a) Wall support bracket.
b) Flexible, 3/8-inch (10-mm) metal-encased hose with a minimum length of 29 inches (737 mm) and supported by spiral spring.
c) Spray-head assembly with lockable lever handle.
10) Accessories:
a) Cone with adaptor ring.
i. Size: 12 inches (305 mm) **OR** 15 inches (381 mm) **OR** 18 inches (457 mm), **as directed**.
b) Cone cover in size that matches cone.
c) Silver sorter.
d) Trough collar connection.
11) Electrical Service: Equip unit for connection to service indicated on Drawings.

C. Cooking Equipment
1. Ranges:
a. Description:
1) Top Configuration:
a) Open-Burner Unit:
i. Standard Burners: Four **OR** Six **OR** Eight **OR** Four, step-up type, **as directed**.
ii. Wok **OR** Saute, **as directed**, Head: as directed by the Owner.
b) Griddle: Flat **OR** Raised, **as directed**.
c) Radiant Broiler: as directed by the Owner.
2) Base Configuration:
a) Standard Oven(s): One **OR** Two, **as directed**.
b) Convection Oven(s): One **OR** Two, **as directed**.
c) Storage Base: One.
3) Accessories:
a) High **OR** Double-deck, **as directed**, back shelf.
b) Stainless-steel sides.
c) Stainless-steel back.
d) Legs for curb base.
e) Toe Base: 4 inches (102 mm) high.
f) Casters: as directed by the Owner.
g) Oven Rack(s): One for each oven.

4) Electrical Service: Equip unit for connection to service indicated on Drawings.
5) Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.

2. Deep Fat Fryers:
   a. Description: Electric fryer, solid-state controls **OR** Electric, programmable computer controls **OR** Gas fryer, **as directed**.
      1) Oil Capacity: 40 lb (18 kg) **OR** 85 lb (39 kg), **as directed**.
      2) Accessories:
         a) Stainless-steel sides.
         b) Stainless-steel fry tank.
         c) Stainless-steel fry tank cover.
         d) Casters: as directed by the Owner.
         e) Automatic basket lifts.
         f) Single Fry Baskets: as directed by the Owner.
         g) Twin Fry Baskets: as directed by the Owner.
         h) Triple Fry Baskets: as directed by the Owner.
         i) Quick gas-service disconnect and flexible hose.
      3) Electrical Service: Equip unit for connection to service indicated on Drawings.
      4) Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
3. Steam Jacketed Kettles:
   a. Description: Stainless steel, Type 304.
      1) Type: Stationary **OR** Tilting, **as directed**.
      2) Steam Source: Electrically heated, self-contained **OR** Direct, **as directed**.
         a) Maximum **OR** Operating, **as directed**, Steam Pressure: 50 psig (345 kPa) **OR** 25 psig (172 kPa), **as directed**.
      3) Capacity: 10 quarts (9.5 L) **OR** 20 gal. (76 L), **as directed**.
      4) Accessories:
         a) Basket insert.
         b) Lift-off cover.
         c) Single **OR** Double, **as directed**,-pantry water filler.
         d) Tangent Drawoff: 2 inches (50 mm) **OR** 3 inches (76 mm), **as directed**.
         e) Disc Strainer: 1/8 inch (3 mm), perforated **OR** solid, **as directed**.
         f) Interior Finish: Manufacturer's standard **OR** Stainless steel, Type 316, **as directed**.
         g) Cold-water jacket cooling.
         h) Steam trap assemblies.
         i) Kettle brush kit.
      5) Electrical Service: Equip unit for connection to service indicated on Drawings.
   b. Stainless-Steel Sheet: ASTM A 240/A 240M, austenitic stainless steel, type as indicated.
   c. Stainless-Steel Finish: Directional satin finish, No. 4.
4. Ovens:
   a. Description: Electric convection **OR** Gas convection **OR** Rotisserie, **as directed**.
      1) Single deck **OR** Double deck **OR** Single deck with open stand, **as directed**.
      2) Accessories:
         a) Oven Rack(s): One per oven chamber.
         b) Stainless-steel drip pan.
         c) Down-draft flue diverter.
         d) Stacking kit.
      3) Electrical Service: Equip unit for connection to service indicated on Drawings.
      4) Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
5. Microwave Ovens:
   a. Description: 1200-W cooking power.
      1) Electrical Service: Equip unit with plug and cord for 120-V service.
6. Coffee Urns:
   a. Description: Single **OR** Twin **OR** Triple, **as directed**, urn.
      1) Capacity: 3 gal. (11 L) **OR** 6 gal. (23 L) **OR** 10 gal. (38 L), **as directed**, per liner.
      2) Type: Electric **OR** Gas **OR** Steam, **as directed**, heated.

3) Agitator: Automatic **OR** Push button, **as directed**.
4) Spray Arm: With **OR** Without, **as directed**, bypass.
5) Timer: Digital **OR** Electromechanical, **as directed**.
6) Accessories:
a) Fill/Dispense: as directed by the Owner.
b) Multiple Faucet: as directed by the Owner.
c) Filtering: Permanent, stainless-steel, woven-wire cloth **OR** Disposable filter paper, **as directed**.
d) Finish: Manufacturer's standard **OR** Brass body and trim **OR** Copper body and brass trim, **as directed**.

b. Electrical Service: Equip unit for connection to service indicated on Drawings.
c. Gas Service: Natural **OR** Liquefied propane, **as directed**, gas.
d. Operating Steam Pressure: As indicated on Drawings **OR** As directed.

D. Self-Contained Refrigeration Equipment
1. Refrigerators **OR** Freezers, **as directed**:
a. Description: Reach-in **OR** Roll-in **OR** Pass-through, **as directed**, type.
1) Exterior Finish: Stainless steel.
2) Interior Finish: Stainless steel **OR** Manufacturer's standard, **as directed**.
3) Doors: Full length **OR** Half length **OR** In configuration shown on Drawings, **as directed**.
4) Accessories:
a) Casters.
b) Stainless-steel back with rear louvers.
c) Re-hinging feature for doors.
d) Hinged glass doors and fluorescent fixtures.
e) Tray Slides: For sheet pans.
f) Chrome-Plated **OR** Stainless-Steel, **as directed**, Shelves: Quantity, as directed by the Owner.
g) Loading Rack: as directed by the Owner.
h) Transfer Carriage: as directed by the Owner.
5) Electrical Service: Equip unit with plug and cord for service indicated on Drawings.
2. Undercounter Refrigerators **OR** Freezers, **as directed**:
a. Description: Compact unit with rear-mounted, self-contained refrigeration system.
1) Accessories:
a) Stainless-steel top with backsplash.
b) Stainless-steel back panel.
c) Casters: 6 inches (152 mm) **OR** 4 inches (102 mm) **OR** 3-1/2 inches (89 mm), **as directed**, high.
d) Utility Base: 6 inches (152 mm) high.
e) Shelves: Description and quantity, as directed by the Owner.
f) Stacking kit.
2) Electrical Service: Equip unit with plug and cord for service indicated on Drawings.
3. Merchandiser Refrigeration Units:
a. Description: Curved-glass, self-contained refrigerator **OR** Sliding-glass, self-contained refrigerator **OR** Sliding-glass, self-contained freezer, **as directed**.
1) Exterior Finish: Manufacturer's standard **OR** Stainless steel, **as directed**.
2) Interior Finish: Manufacturer's standard **OR** Stainless steel **OR** White, **as directed**.
3) Accessories:
a) Door locks.
b) Fluorescent Light Fixtures: Quantity, as directed by the Owner.
c) Base: as directed by the Owner.
d) Casters: as directed by the Owner.
e) Legs: as directed by the Owner.
f) Chrome-Plated Shelves: Quantity, as directed by the Owner.

4) Electrical Service: Equip unit with plug and cord for service indicated on Drawings.

4. Ice-Making Machine:
   a. Description: Undercounter **OR** Freestanding, **as directed**, units.
      1) Production: Ice cubes **OR** cubes, dice **OR** cubes, half dice **OR** flakes **OR** chiplets (compacted flake ice), **as directed**.
      2) Capacity: as directed by The Owner per 24-hour period.
      3) Accessories:
         a) Storage Bin: as directed by the Owner..
            i. Stainless-steel stand and legs.
         b) Water filter.
      4) Electrical Service: Equip unit for connection to service indicated on Drawings.

E. Walk-In Refrigeration Equipment
   1. Walk-in Refrigeration Units:
      a. Description: Cooler **OR** Freezer **OR** Two-compartment unit, with cooler and freezer compartments, **as directed**.
         1) Wall and Ceiling Panels: Interlocking insulating panels.
         2) Floors: Insulated floor panels **OR** Field installed; provide manufacturer's standard insulated floor screed, **as directed**.
         3) Doors:
            a) Hinges: Two per door **OR** Self-closing and spring loaded; three per door,. **As directed**.
            b) Latch: Edge-mounted, positive-type latch with cylinder lock.
            c) Include safety-release handle that opens door from inside when door is locked.
         4) Door Accessories:
            a) Vision port.
            b) Pressure relief port.
            c) Threshold: Stainless steel, factory installed.
            d) Anticondensate heater at freezer doors.
         5) Vaporproof Lighting Fixtures: Incandescent fixture with 100-W lamp.
            a) Control: Neon pilot light and toggle switch located on exterior of door panel.
            b) Quantity: One per compartment, located on door panel.
         6) Refrigeration System: Self-contained, mounted on unit **OR** Remote system with preassembled condensing unit and evaporator assemblies.
            a) Exterior Condensing Units: Include winter control, crankcase heater, and enclosed weatherproof housing.
            b) Operating Temperature: as directed by the Owner.
         7) Temperature Monitoring System: Electronic monitoring and remote audible alarm system that warns when temperatures register 10 deg F (6 deg C) above or below set temperature.
         8) Closure Panels and Trim: Include closure panels and trim.
         9) Electrical Service: Equip unit for connection to service indicated on Drawings.
      b. Finishes:
         1) Exposed Exterior Finish: Stucco-patterned aluminum **OR** Smooth, mill-finished aluminum **OR** White-painted aluminum, **as directed**.
         2) Unexposed Exterior Finish: Stucco-patterned, metallic-coated steel.
         3) Interior Finish: Stucco-patterned aluminum **OR** Smooth, mill-finished aluminum **OR** White-painted aluminum, **as directed**.
         4) Closure Panels and Trim: Matched to exposed exterior finish of panels.

F. Powered Food-Preparation Equipment
   1. Mixers **OR** Slicers **OR** Meat Saws **OR** Peelers, **as directed**:
      a. Description: as directed by the Owner.
      b. Accessories: as directed by the Owner.
      c. Electrical Service: Equip unit with plug and cord for service indicated on Drawings.

G. Warewashing Equipment
1. Warewashing Machines:
a. Description: Dishwashing, single tank **OR** Dishwashing, double tank **OR** Dishwashing, rackless conveyor **OR** Dishwashing, with circular conveyor table **OR** Pot and pan washing, two racks **OR OR** Pot and pan washing, one rack, **as directed**.
1) Capacity: as directed by the Owner.
2) Accessories: as directed by the Owner.
3) Electrical Service: Equip unit for connection to service indicated on Drawings.

H. Serving Equipment
1. Modular Counters:
a. Description: Hot food **OR** Refrigerated salad **OR** Ice-cooled salad **OR** Sliding-glass door refrigerated **OR** Frost-top **OR** Sandwich **OR** Pizza **OR** Refrigerated-chest **OR** Dual-temperature **OR** Tray-starter **OR** Storage **OR** Cashier, **as directed**, module.
1) Cabinet Face Panels: Manufacturer's standard.
2) Accessories:
a) Tray slide.
b) Work shelf.
c) Casters.
d) Electrical receptacle.
e) Cam-action latch locks with trigger release to mate with adjoining modular counters.
f) Tempered-glass, food-protector shield.
3) Electrical Service: Equip unit for connection to service indicated on Drawings.
4) Color: As selected from manufacturer's full range.

I. Utility Distribution Systems
1. Utility Distribution Systems:
a. Description: Overhead **OR** Counter **OR** Island **OR** Tray-slide **OR** Steam **OR** Wall-mounted, **as directed**, system.
b. Accessories: as directed by the Owner.

J. Miscellaneous Materials
1. Installation Accessories, General: NSF certified for end-use application indicated.
2. Elastomeric Joint Sealant: ASTM C 920; silicone **OR** urethane, **as directed**. Type S (single component), Grade NS (nonsag), Class 25, Use NT (nontraffic) related to exposure, and Use M, G, A, or O as applicable to joint substrates indicated.
a. Public Health and Safety Requirements:
1) Sealant is certified for compliance with NSF standards for end-use application indicated.
2) Washed and cured sealant complies with the FDA's regulations for use in areas that come in contact with food.
b. Cylindrical Sealant Backing: ASTM C 1330, Type C, closed-cell polyethylene, in diameter greater than joint width.

K. Finishes
1. Stainless-Steel Finishes:
a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
1) Run grain of directional finishes with long dimension of each piece.
2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

2. Powder-Coat Finishes: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard, baked-polymer, thermosetting powder finish. Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

1.3 EXECUTION

A. Installation
1. Install foodservice equipment level and plumb, according to manufacturer's written instructions.
   a. Connect equipment to utilities.
   b. Provide cutouts in equipment, neatly formed, where required to run service lines through equipment to make final connections.
2. Complete equipment assembly where field assembly is required.
   a. Provide closed butt and contact joints that do not require a filler.
   b. Grind field welds on stainless-steel equipment until smooth and polish to match adjacent finish.
3. Install equipment with access and maintenance clearances that comply with manufacturer's written installation instructions and with requirements of authorities having jurisdiction.
4. Install cabinets and similar equipment on bases in a bed of sealant.
5. Install closure-trim strips and similar items requiring fasteners in a bed of sealant.
6. Install joint sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Produce airtight, watertight, vermin-proof, sanitary joints.

B. Cleaning And Protecting
1. After completing installation of equipment, repair damaged finishes.
2. Clean and adjust equipment as required to produce ready-for-use condition.
3. Protect equipment from damage during remainder of the construction period.

C. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain foodservice equipment.

END OF SECTION 11425

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Task	Specification	Specification Description
11425	01352	No Specification Required

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SECTION 11481 - GYMNASIUM EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for gymnasium equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following gymnasium equipment:
   a. Basketball equipment.
   b. Volleyball equipment.
   c. Badminton equipment.
   d. Exercise equipment.
   e. Safety pads.

C. Definitions
1. FIBA: International Basketball Federation (Federation Internationale de Basketball Amateur).
2. FIVB: International Volleyball Federation (Federation Internationale de Volleyball).
3. IBF: International Badminton Federation.
4. NAGWS: The National Association for Girls and Women in Sport.
5. NCAA: The National Collegiate Athletic Association.
6. NFHS: The National Federation of State High School Associations.
7. USAV: USA Volleyball.

D. Performance Requirements
1. Seismic Performance: Provide basketball backboards capable of withstanding the effects of earthquake motions determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

E. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
   a. Product Data for Credit EQ 4.4: For particleboard, documentation indicating that product contains no urea formaldehyde.
3. Shop Drawings: For gymnasium equipment. Include plans, elevations, sections, details, attachments to other work.
4. Structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation including loads, point reactions, and locations for attachment of gymnasium equipment to structure.
5. Coordination Drawings: Court layout plans, drawn to scale, and coordinating floor inserts, game lines, and markers applied to finished flooring.
6. Samples: For each type of gymnasium equipment indicated.
7. Operation and maintenance data.
8. Warranty: Special warranty specified in this Section.

F. Quality Assurance
1. Installer Qualifications: Fabricator of products **OR** An employer of workers trained and approved by manufacturer, **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

3. Composite Wood Products: Made without urea formaldehyde.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of gymnasium equipment that fail in materials or workmanship within five **OR** 10, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Materials
1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
   a. Extruded Bars, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
   b. Cast Aluminum: ASTM B 179.
   c. Flat Sheet: ASTM B 209 (ASTM B 209M).
2. Steel: Comply with the following:
   a. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
   b. Steel Tubing: ASTM A 500 or ASTM A 513, cold formed.
   c. Steel Sheet: ASTM A 1011/A 1011M.
3. Support Cable: 1/4-inch- (6-mm-) diameter, 7x19 **OR** Manufacturer's standard, **as directed**, galvanized steel aircraft cable with a breaking strength of 7000 lb (3175 kg). Provide fittings complying with cable manufacturer's written instructions for size, number, and method of installation.
4. Support Chain and Fittings: Grade 80 hardened alloy steel chain rated for overhead lifting, ASTM A 391/A 391M, with commercial-quality, hot-dip galvanized **OR** zinc-plated, **as directed**, steel connectors and hangars.
5. Castings and Hangers: Malleable iron, ASTM A 47/A 47M, grade required for structural loading.
6. Softwood Plywood: DOC PS 1, exterior.
7. Particleboard: ANSI A208.1, made with adhesive containing no urea formaldehyde.
8. Equipment Wall-Mounting Board: Wood, transparent **OR** neutral-color painted, **as directed**, finish, size, and quantity as required to mount gymnasium equipment according to manufacturer's written instructions.
9. Anchors, Fasteners, Fittings and Hardware: Manufacturer's standard corrosion-resistant or noncorrodible units; concealed; tamperproof, vandal- and theft-resistant design.
10. Grout: Nonshrink, nonmetallic, premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107 with minimum strength recommended in writing by gymnasium equipment manufacturer.

B. Basketball Equipment
1. General: Provide equipment complying with requirements in FIBA's "FIBA Basketball Rule Book **OR** NCAA's "NCAA Basketball Rule Book **OR** NFHS's "NFHS Basketball Rule Book," **as directed**.
2. Protruding fasteners or exposed bolt heads on front face of backboards are not permitted.
3. Overhead-Supported, Wall-Braced, **as directed**, Backboard:
   a. Stationary Type: Manufacturer's standard assembly.
   b. Folding Type: Provide manufacturer's standard assembly for forward-folding, front-braced **OR** forward-folding, rear-braced **OR** backward-folding **OR** side-folding, **as directed**, backboard, with hardware and fittings to permit folding.
   c. Framing: Steel pipe, tubing, and shapes. Design framing to minimize vibration during play.
      1) Center-Mast Frame: Welded **OR** Welded and bolted or clamped, **as directed**, with side sway bracing.
      2) Dual-Mast Frame: Welded **OR** Welded and bolted or clamped, **as directed**, with cross bracing.

3) Finish: Manufacturer's standard primer for field finishing **OR** powder-coat finish, **as directed**.

d. Goal Height Adjuster: Adjustable from 8 to 10 feet (2.4 to 3 m) with gear-drive mechanism, locking in any position within adjustment range, with visible height scale attached to side of framing.

1) Operation: Manual with detachable crank handle.

OR

Operation: Electric with integral gear-drive motor, with limit switches preset to goal heights, and one detachable electric control device(s).

4. Wall-Mounted Backboards: Complete assembly extending from wall, including support framing to building structure, bracing, cables, chains, pulleys, fittings, hardware, pipe anchors, equipment pads, and fasteners.

a. Stationary Type: Provide manufacturer's standard assembly for stationary backboard.

b. Folding Type: Provide manufacturer's standard assembly for upward-folding **OR** side-folding, **as directed**, backboard, with hardware and fittings to permit folding.

c. Framing: Steel pipe, tubing, and shapes. Design framing to minimize vibration during play.

1) Finish: Manufacturer's standard primer for field finishing **OR** powder-coat finish, **as directed**.

d. Extension: 6 inches (152 mm) **OR** 12 inches (305 mm) **OR** 18 inches (457 mm) **OR** 24 to 48 inches (610 to 1220 mm) **OR** 48 to 120 inches (1220 to 3050 mm) **OR** As indicated, **as directed**.

e. Goal Height Adjuster: Adjustable from 8 to 10 feet (2.4 to 3 m) with gear-drive mechanism, locking in any position within adjustment range, with visible height scale attached to side of framing.

1) Operation: Manual with detachable crank handle.

OR

Operation: Electric with integral gear-drive motor, with limit switches preset to goal heights, and one detachable electric control device(s).

5. Backboard Safety Device: Designed to limit free fall if support cable, support chain, pulleys, fittings, winch, or related components fail; with mechanical automatic reset; 6000-lb (2722-kg) load capacity; one per folding backboard **OR** where indicated, **as directed**.

a. Retractor Device: Pulley-type **OR** Spring-activated, reel-type **OR** Manufacturer's standard, **as directed**, device designed to retract both support and safety cables, chains, and straps away from play of the basketball when backboard is in playing position; one per folding backboard **OR** where indicated, **as directed**.

6. Winch: Hoist, consisting of heavy-duty, fully enclosed worm-gear, brake, cable drum, cable, and fittings, for mounting on wall with equipment mounting board; designed to move and hold backboard in any raised or lowered position.

a. Operation: Manual winch with detachable hand crank.

b. Portable Winch Operator: One portable electric motor-drive device(s), including adaptor to fit crank mechanism.

7. Backboard Electric Operator: Provide operating machine of size and capacity recommended by manufacturer for equipment specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, and remote controls. Coordinate wiring requirements and electrical characteristics with building electrical system.

a. Operator Type: Cable drum with grooved drum and cable tension device to automatically take up cable slack and retain cable in grooves.

b. Operator Mounting: Wall-mounting board.

c. Motor Characteristics: Sufficient to start, accelerate, reverse, and operate connected loads at designated speeds within installed environment and with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1, and the following:

d. Voltage: 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.

e. Horsepower: 1/2 **OR** 3/4 **OR** 1, **as directed**, hp.

f. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
g. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
h. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
i. Phase: One.
j. Remote-Control Station(s): NEMA ICS 6, Type 1 enclosure for surface **OR** recessed or flush, **as directed**, mounting, momentary-contact, three-position switch-operated control with up, down, and off functions.
   1) Group Key Switch Control Stations: One switch per each backboard **OR** two backboards, **as directed**.
   2) Keys: Provide one key **OR** two keys **OR** one set of dual keys **OR** two sets of dual keys **OR** dual keys, one key for up and one for down, **as directed**, per station.
   3) Switches, Ganged: Single faceplate with multiple switch cut-outs for two switches operating four backboards **OR** for three switches operating six backboards **OR** for four switches operating eight backboards **OR** for 5 switches operating 10 backboards **OR** for 6 switches operating 12 backboards **OR** as indicated, **as directed**.
   4) Control Station Enclosure: Provide prime-painted metal enclosure with integrally formed padlock hasps **OR** key access with two sets of keys per enclosure, **as directed**.
   5) Radio Controls: Digital system consisting of code-compatible universal coaxial receiver, one per backboard winch, and two portable multiple-channel transmitters for operating two **OR** four **OR** up to nine, **as directed**, backboards individually with up and down functions.
k. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop basketball equipment at fully retracted and fully lowered positions.

8. Basketball Backboard:
   a. Shape and Size:
      1) Rectangular, 72 by 42 inches (1800 by 1050 mm) **OR** 72 by 48 inches (1800 by 1200 mm), **as directed**, width by height, with rounded corners, **as directed**.
      2) Fan shaped, 54-inch (1370-mm) maximum width by 35-inch (890-mm) **OR** 39-inch (990-mm), **as directed**, maximum height.
   b. Backboard Material: With predrilled holes or preset inserts for mounting goals, and as follows:
      1) Fiberglass: Not less than 1-1/2-inch- (38-mm-) thick composite backboard consisting of not less than two 3/16-inch- (5-mm-) thick, molded fiberglass panels laminated together over faces and edges encapsulating a 3/4-inch (19-mm) honeycomb core, reinforced at goal and backboard mountings, or wood panel product core; with threaded inserts or embedded anchors for mounting backboard corners to support framing at standard mounting centers.
      2) Glass: Not less than 1/2-inch- (13-mm-) thick, transparent tempered glass. Provide glass with impact-absorbing resilient rubber or PVC gasket around perimeter in a fully welded, painted steel **OR** brushed-natural-finish, extruded-aluminum, **as directed**, frame, with steel subframe, reinforcement, and bracing, including center-strut frame reinforcement, **as directed**, and with mounting slots for mounting backboard frame to backboard support framing.
         a) Standard Mount: Provide steel corner reinforcement with mounting slots for mounting backboard frame to backboard support framing at standard mounting centers.
         b) Direct Mount: Designed for mounting backboard frame to center mast of backboard framing to maximize relief of stresses on backboard frame and glass.
         c) Rim-Restraining Device: Complying with NCAA and NFHS rules and designed to ensure that basket remains attached if glass backboard breaks.

3) Steel: Single-piece, steel face sheet, not less than 0.1046-inch (2.7-mm) nominal thickness, with 1-1/2-inch- (38-mm-) deep, roll-edged perimeter flange and with steel-reinforced, welded frame welded to back side of backboard; with mounting slots for mounting backboard frame to backboard support framing at standard mounting centers.
4) Hardwood or Particleboard: Not less than 1-1/2-inch- (38-mm-) thick backboard consisting of not less than 1/32-inch- (0.8-mm-) thick, melamine- or phenolic-resin-impregnated cellulose and paper laminate over front and back sides of 1-1/2-inch (38-mm) hardwood or particleboard core; with painted edges and corners and with threaded inserts or slotted brackets for mounting backboard corners to backboard support framing at standard mounting centers.

c. Target Area and Border Markings: Permanently etched in white color, marked in pattern and stripe width according to referenced rules **OR** manufacturer's standard pattern and stripe width, **as directed**.
d. Target Area and Border Markings: Marked in pattern, stripe width, and color according to referenced rules **OR** orange, with manufacturer's standard pattern and stripe width **OR** black, with manufacturer's standard pattern and stripe width, **as directed**.
e. Finish: Manufacturer's standard factory-applied, white background.

9. Goal Mounting Assembly: Compatible with goal, backboard, and support framing; with hole pattern 5 inches (127 mm) o.c. horizontally and vertically **OR** 5 inches (127 mm) o.c. horizontally and 4 inches (102 mm) o.c. vertically **OR** 5 inches (127 mm) o.c. horizontally and 4-1/2 inches (114 mm) o.c. vertically **OR** that is manufacturer's standard, **as directed**, for goal attachment.
a. Glass Backboard Goal Mounting Assembly: Goal support framing and reinforcement designed to transmit load from goal to backboard frame and to minimize stresses on glass backboard.
b. Direct Mount: Designed for mounting goal directly and independently to center mast of backboard support framing so no force, transmitted by ring, is directly applied to backboard and rigidity and stability of goal are maximized.

10. Basketball Goals: Complete with flanges, braces, attachment plate, and evenly spaced loops welded around underside of ring.
a. Single-Rim Basket Ring Competition Goal: Materials, dimensions, and fabrication complying with referenced rules **OR** per manufacturer's standard design, **as directed**.
b. Double-Rim Basket Ring: Fabricated with 2 rims, each consisting of 5/8-inch- (16-mm-) diameter **OR** consisting of one 1/2-inch- (13-mm-) diameter and one 5/8-inch- (16-mm-) diameter **OR** manufacturer's standard-diameter, **as directed**, steel rod welded into 18-inch (450-mm) ID rings.
c. Type: Fixed, nonmovable.
OR
Type: Movable, breakaway design with manufacturer's standard breakaway mechanism and rebound characteristics identical to those of fixed, nonmovable ring.
OR
Type: Movable, breakaway design with manufacturer's standard breakaway mechanism including positive-lock, preset pressure release, set to release at 230-lb (105-kg) **OR** 180- and 230-lb (82- and 105-kg), **as directed**, load, and automatic reset. Provide movable ring with rebound characteristics identical to those of fixed, nonmovable ring.
d. Mount: Front **OR** Rear, **as directed**.
e. Net Attachment: Loops for tying net to rim **OR** No-tie loops for attaching net to rim without tying **OR** Tube-tie for attaching net to rim, **as directed**.
f. Finish: Manufacturer's standard **OR** Powder-coat, **as directed**, finish.

11. Basketball Nets: 12-loop-mesh net, between 15 and 18 inches (400 to 450 mm) long, sized to fit rim diameter, and as follows:
a. Cord: Made from white cotton **OR** nylon **OR** plastic, **as directed**.
b. Competition Cord: Antiwhip, made from white nylon cord not less than 120- or more than 144-gm thread.
c. Chain: Nontangle, nonstretch design that will not scratch or impede the ball, made from zinc-coated steel chain.

12. Backboard Safety Pads: Designed for backboard thickness indicated and extending continuously along bottom and up sides of backboard and over goal mounting and backboard supports as required by referenced rules **OR** per manufacturer's standard design **OR** indicated, **as directed**.
    a. Attachment: Peel-and-stick tape **OR** Adhesive **OR** Bolt-on **OR** Manufacturer's standard, **as directed**.
    b. Color: Black **OR** Gray **OR** Manufacturer's standard color **OR** As selected from manufacturer's full range, **as directed**.

C. Volleyball Equipment
1. General: Provide equipment complying with requirements in FIVB's "Official Volleyball Rules **OR** NAGWS's "NAGWS Volleyball Rulebook **OR** NFHS's "NFHS Volleyball Rule Book **OR** USAV's "USA Volleyball Rule Book," **as directed**.
2. Floor Insert: Solid-brass **OR** Chrome-finished steel **OR** Aluminum, **as directed**, floor plate; and steel pipe sleeve, concealed by floor plate, with capped bottom end, sized with ID to fit post standards, not less than 9 inches (230 mm) long **OR** 12 inches (300 mm) long **OR** length required, **as directed**, to securely anchor pipe sleeve in structural floor **OR** below finished floor in concrete footing **OR** as indicated, **as directed**; with anchors designed for securing floor insert to floor substrate indicated; one per post standard **OR** quantity as indicated, **as directed**.
    a. Floor Plate: Self-locking, **OR** Lockable, **OR** Manufacturer's standard, **as directed**, hinged access cover, designed to be flush with adjacent flooring. Provide one **OR** two, **as directed**, tool(s) for unlocking access covers.
    OR
    Floor Plate: Self-locking, **OR** Lockable, **OR** Manufacturer's standard, **as directed**, hinged access cover, recessed to accept finish flooring matching and designed to be level with adjacent flooring. Provide one **OR** two, **as directed**, tool(s) for unlocking access covers.
    OR
    Floor Plate: Lockable swivel access cover, designed for use with floating wood floors and to be flush with adjacent flooring. Provide one **OR** two, **as directed**, tool(s) for unlocking access covers.
3. Post Standards: Removable, paired volleyball post standards and center post standard for multicourt play as indicated. Fixed **OR** Adjustable, telescoping, **as directed**, height. Designed for easy removal from permanently placed floor insert supports. Fabricated from steel **OR** extruded-aluminum **OR** combined steel and extruded-aluminum **OR** manufacturer's standard metal, **as directed**, pipe or tubing, with nonmarking plastic or rubber end cap or floor bumper to protect permanent flooring. Finished with manufacturer's standard factory-applied, baked powder-coating finish complying with finish manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness or plated metal finish.
    a. Nominal Pipe or Tubing Diameter: 3-inch (75-mm) **OR** 3-1/2-inch (89-mm) **OR** 4-inch (102-mm), **as directed**, OD at base.
    b. Net Height Adjuster: Track or rail system and lock mechanism designed for infinite **OR** Sliding collar and lock mechanism designed for infinite **OR** Preset net hooks designed for incremental **OR** Manufacturer's standard mechanism for, **as directed**, height adjustment, complete with fittings; designed for positioning net at heights indicated.
    c. Telescopic and Net Height Adjuster System: Provide infinitely adjustable system consisting of screw rod, gear, and crank or constant-tension spring and pulley assist and **OR** incrementally adjustable system with predrilled holes and pin **OR** Manufacturer's standard telescoping system with, **as directed**, locking device, telescopic post, and fittings for holding net at selected height; designed for height adjustment of post standard to position net at heights indicated.
        1) Net Heights: Between sitting volleyball net height and boys'/men's volleyball net height, 36 and 95-5/8 inches (910 and 2430 mm) **OR** tennis net height and boys'/men's volleyball net height, 42 and 95-5/8 inches (1066 and 2430 mm) **OR** for age 12 and under net height and boys'/men's volleyball net height, 84 and 95-5/8 inches (2130 and 2430 mm), **as directed**, or more.

d. Height Markers: Clearly marked at regulation play heights for elementary school **OR** girls/women **OR** boys/men **OR** sitting volleyball **OR** tennis, **as directed**.

4. Net: 32 feet (9.75 m) long and as follows; 1 per pair of paired post standards **OR** 2 per every center post standard, **as directed**:
   a. Width and Mesh: 36 inches (910 mm) with 4-1/2-inch- (114-mm-) square mesh made of black polyester string.
      1) Hem Band Edges: White, 2-inch- (50-mm-) wide top binding; black, 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, wide bottom and side bindings; tie offs at top and bottom of each side end of net; and 1/4-inch- (6-mm-) diameter rope, at least 42 feet (12.8 m) long, threaded through top hem of binding.
   b. Width and Mesh: Competition volleyball net, 36 inches (910 mm) **OR** 39 inches (990 mm), **as directed**, with 4-inch- (102-mm-) square knotless, **as directed**, mesh made of black nylon string.
      1) Hem Band Edges: White, not less than 2-inch- (50-mm-) wide top, bottom, and side bindings; tie offs at top, bottom and midpoint of each side end of net **OR** not less than 1-inch- (25-mm-) wide tension straps at top, bottom and midpoint of each side end of net, **as directed**; end sleeves for dowels; and lines with linkage fittings threaded through top and bottom hems of binding. Provide lengths of lines and linkage fittings as required to properly connect to and set up net for post standard spacing indicated on Drawings.
         a) Top Line: Not less than 1/4-inch- (6-mm-) diameter rope **OR** 1/8-inch- (3-mm-) diameter, galvanized or coated steel cable, **as directed**.
         b) Bottom Line: Not less than 1/4-inch- (6-mm-) diameter rope **OR** 1/8-inch- (3-mm-) diameter, galvanized or coated steel cable, **as directed**.
   c. Dowels: Not less than 1/2-inch- (13-mm-) diameter fiberglass or 1-inch- (25-mm-) diameter wood. Provide two dowels per net threaded through each side hem sleeve for straightening net side edges.
   d. Net Antennas: 3/8-inch- (9.5-mm-) diameter, high-tensile-strength, extruded fiberglass or plastic rods, 72 inches (1800 mm) long, extending above top hem band of net, with alternating white and red bands according to competition rules. Provide two antennas per net.
      1) Clamps: Designed to secure antenna to top and bottom of net.
   e. Boundary Tape Markers: 2-inch- (50-mm-) wide white strip with sleeve for securing net antenna, **as directed**, secured to net top and bottom with hook-and-loop attachment. Provide two tape markers per net for marking court boundaries.
5. Net Tensioning System: Designed to adjust and hold tension of net. Fully enclosed, nonslip worm-gear-type **OR** rack-and-pinion-type **OR** ratchet-type **OR** manufacturer's standard-type, **as directed**, winch with cable length and fittings for connecting to net lines, positive-release mechanism, and permanently fixed **OR** removable **OR** manufacturer's standard, **as directed**, handle. Mount net tensioner on post standard at side away from court. Provide end post with post top pulley. Provide opposing post with welded steel loops, hooks, pins, or other devices for net attachment and post top grooved line guide.
6. Bottom Net Lock Tightener: Provide manufacturer's standard quick-release-type tension strap, spring-loaded self-locking tensioner, turnbuckle, pulley, or other device and linkage fittings designed to quickly and easily tighten bottom line or net.
7. Judges' Stands: Provide manufacturer's standard **OR** standard adjustable-height, **as directed**, units designed to be freestanding, folding for storage **OR** freestanding, folding for storage with wheels for transporting **OR** attached to and supported by post standard, **as directed**. Fabricate units of welded steel tubing with finish and color to match post standards.
8. Safety Pads: Comply with NCAA and NFHS requirements, **as directed**. Provide pads consisting of not less than 1-inch- (25-mm-) **OR** 1-1/4-inch- (32-mm-), **as directed**, thick, multiple-impact-resistant polyurethane **OR** crosslinked or closed-cell polyethylene **OR** manufacturer's standard, **as directed**, foam filler covered by puncture- and tear-resistant, not less than 14-oz./sq. yd. (475-g/sq. m) PVC-coated polyester, treated with fungicide for mildew resistance, **OR** not less than 14-oz./sq. yd. (475-g/sq. m) nylon-reinforced PVC, **OR** molded PVC, **OR** manufacturer's standard, **as directed**, fabric cover; with fire-test-response characteristics indicated, and lined with fire-

retardant liner, **as directed**. Provide pads with hook-and-loop closure or attachments for the following components:

a. Post Standards: Wraparound **OR** 3- or 4-sided, **as directed**, style, designed to totally enclose each standard to a height of not less than 66 inches (1680 mm) **OR** 72 inches (1830 mm), **as directed**; 1 per post.

b. Net Lines: Four per net.

c. Judges' Stands: Designed to totally enclose each unit.

d. Fabric Cover Flame-Resistance Ratings: Passes NFPA 701.

e. Fabric Color: Match school colors **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**.

f. Graphics: Custom graphics as indicated.

9. Post Standard Transporter: Manufacturer's standard wheeled unit designed for transporting a single post.

10. Wall Storage Rack: Manufacturer's standard unit designed for mounting on walls and for storing post standards in vertical position with retaining arms, fittings for padlock, and mounting hardware; number of units as required to provide storage for specified equipment.

11. Storage Cart: Manufacturer's standard wheeled unit designed for transporting and storing volleyball equipment and passing through 36-inch- (910-mm-) wide or wider door openings. Fabricate units of welded steel tubing with heavy-duty casters, including not less than two swivel casters. Fabricate wheels from materials that will not damage or mark floors; number of units as required to provide transport and storage for specified equipment.

D. Badminton Equipment

1. General: Provide equipment complying with requirements in IBF's "The Laws of Badminton."

2. Floor Insert: Solid-brass floor plate with hinged, **as directed**, access cover and steel pipe sleeve with capped bottom end; sized with ID to fit post standards, not less than 5-1/4 inches (133 mm) long **OR** length required, **as directed**, to securely anchor pipe in structural floor **OR** below finished floor in concrete footing **OR** as indicated, **as directed**; one per post standard **OR** quantity as indicated, **as directed**.

3. Floor Insert Adaptor: Pipe sleeve adaptor to convert volleyball floor insert sleeve to fit badminton post standard; one per badminton post standard **OR** quantity as indicated, **as directed**.

4. Post Standards: Paired badminton post standards and center post standard for multicourt play. Designed for easy removal from permanently placed floor insert supports. Fabricated from steel pipe or tubing, with plastic or rubber end cap or nonmarking floor bumper to protect permanent flooring. Finished with manufacturer's standard factory-applied, baked powder-coat finish complying with finish manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness.

a. Nominal Pipe or Tubing Diameter: 1-1/2-inch (38-mm) **OR** 2-3/8-inch (60-mm), **as directed**, OD at base.

b. Net Height Setting: By preset net hooks.
OR
Net Height Setting: By groove in post standard top and cleat **OR** mechanism to adjust net tension, **as directed**.

5. Net: Competition badminton net, 20 feet (6.1 m) long and as follows; 1 per pair of paired post standards **OR** 2 per every center post standard, **as directed**:

a. Width and Mesh: 30 inches (760 mm) with 3/4-inch- (19-mm-) square mesh made of purple, dark brown, or black nylon string.

1) Hem Band Edges: White, 3-inch- (75-mm-) wide top binding; purple, dark brown, or black 3/4-inch- (19-mm-) wide bottom and side bindings; tie offs at top, bottom, and midpoints **OR** sleeve with dowel, **as directed**, eliminating gap at each side end of net; and not less than 1/8-inch- (3-mm-) diameter rope, at least 42 feet (12.8 m) long, threaded through top hem of binding. Provide lengths of lines and linkage fittings as required to properly connect to and set up net for post standard spacing indicated on Drawings.

E. Exercise Equipment
1. General: Manufacturer's standard equipment wall-mounting board(s).
2. Pull-up Bar: Wall mounted.
   a. Fixed height.
   b. Adjustable Height: In 6-inch (150-mm) increments within a range of 18 inches (460 mm) **OR** 30 inches (760 mm), **as directed**.
   c. Bar Length: Not less than 36 inches (910 mm) **OR** 40 inches (1000 mm) **OR** As indicated, **as directed**.
   d. Bar: Not less than 1-1/16-inch- (27-mm-) diameter, round, plated solid-steel bar.
   e. Support Frame: Steel-angle end brackets attached to wood stringers or steel channels or bars.
   f. Bar Installation Height and Wall Clearance: As indicated at not less than 12 inches (300 mm) from wall.
3. Stall Bar: Wall mounted in a continuous row; each section with not less than 16 rungs.
   a. Size: Each section 96 inches (2400 mm) high by 36 inches (910 mm) wide **OR** As indicated, **as directed**.
   b. Side Rails: Formed-steel tube uprights not less than 1-1/2 by 5 inches (38 by 125 mm) with capped ends; nominal sheet thickness not less than 0.0598 inch (1.52 mm).
   c. Rungs: Not less than 1-3/8-inch- (35-mm-) diameter, round rungs made from hardwood **OR** maple, **as directed**, firmly fixed to side rails to prevent rotating or other movement. Provide equipment with top rung extended 6 inches (150 mm) beyond other rungs.
   d. Extension Arm: Provide equipment with an extension arm and an additional rung extended 20 inches (500 mm) beyond bottom and intermediate rungs.
   e. Number of Sections: As indicated on Drawings **OR as directed,** modular sections, complete with intermediate uprights and terminal uprights without rung holes at finished ends.
4. Horizontal Ladder: Wall mounted; with 12 rungs.
   a. Size: 12 feet (3.7 m) long by not less than 16 inches (400 mm) wide **OR** As indicated, **as directed**.
   b. Side Rails: Steel tubing not less than 1-1/2 by 4 inches (38 by 102 mm) with capped ends; tubing wall thickness not less than 0.083 inch (2.1 mm).
   c. Rungs: Not less than 1-5/16-inch- (33-mm-) diameter, round rungs made from hardwood **OR** maple, **as directed**, firmly fixed to side rails to prevent rotating or other movement.
   d. Support Frame: Not less than 1-5/16-inch- (33-mm-) OD, steel pipe or tubing; with bracing.
   e. Ladder Installation Height and Wall Clearance: As indicated on Drawings **OR as directed,** at 30 inches (760 mm) from wall.
5. Vertical Ladder: Wall mounted; with five to seven horizontal rungs for hand and foot holds.
   a. Size: 60 inches (1500 mm) long by not less than 22 inches (560 mm) wide **OR** As indicated, **as directed**.
   b. Side Rails: Not less than 1-5/16-inch- (33-mm-) OD, round pipe or tubing with rails sloped 10 degrees from wall for climbing.
   c. Rungs: Not less than 1-1/16-inch- (27-mm-) OD, round pipe or tubing rungs firmly welded to side rails.
   d. Ladder Installation Height: As indicated on Drawings **OR as directed**.
   e. Ladder Installation Method: Fixed to wall **OR** Removable, **as directed**.
6. Pegged Board Vertical Climber: Wall-mounted board; size as indicated; with two peg hand holds per board.
7. Climbing Rope: 1-1/2-inch- (38-mm-) diameter rope; with top end securely clamped in fitting designed for attaching to supporting structure indicated.
   a. Description: Three-strand hemp **OR** Synthetic polyfiber **OR** Manufacturer's standard material, **as directed**.
   b. Length: 12 feet (3.7 m) **OR** 16 feet (4.9 m) **OR** 20 feet (6 m) **OR** 24 feet (7.3 m) **OR** Length as required to allow 42 inches (1067 mm) of rope to lie on floor **OR** As indicated, **as directed**.

c. Rope Bottom End: Tied in a turk knot **OR** Tied in a turk knot and fitted with leather sheath **OR** Fitted with heat-shrink-type PVC tube and coated with PVC coating after fitting **OR** Manufacturer's standard, **as directed**.
d. Rubber Balls: Securely fastened every 12 inches (300 mm) **OR** 18 inches (460 mm), **as directed**, along length of rope.
e. Tambourine: 24-inch (600-mm) diameter; not less than 1/2-inch- (13-mm-) thick, painted plywood disk for restricting climbing and for exercise competition.
f. Safety Guard: 3/16-inch (5-mm-) support chain or 1/8-inch- (3-mm-) diameter cable, clamp, and fittings designed for attaching guard to supporting structure indicated.
g. Pipe Beam: Ceiling **OR** Wall and ceiling, **as directed**, mounted; not less than 3-1/2-inch- (89-mm-) OD steel pipe or tubing beam with not less than 2-3/8-inch- (60-mm-) OD drop pipes, bracing, and connectors designed for transferring load and securely attaching to supporting structure indicated.

8. Rope Hoist: Wall attached; consisting of #10 bell cord or 1/4-inch- (6-mm-) diameter, synthetic polyfiber rope, snap swivel fitting, rope adjuster, rope weight, weight bag, pulley, rope cleat, clear-finished wood wall equipment pads for pulley and cleat attachment, clamps, and fasteners.
9. Metal Finish: Manufacturer's standard factory-applied, baked powder-coat finish.
10. Wood Finish: Manufacturer's standard transparent or opaque-painted finish.

F. Safety Pads
1. Safety Pad Surface-Burning Characteristics: ASTM E 84 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction:
a. Flame-Spread Index: 25 or less **OR** 26 to 75 **OR** 76 to 200, **as directed**.
b. Smoke-Developed Index: 450 or less.
2. Pad Coverings: Provide safety pad fabric covering fabricated from puncture- and tear-resistant, not less than 14-oz./sq. yd (475-g/sq. m) PVC-coated polyester or nylon-reinforced PVC fabric treated with fungicide for mildew resistance; with surface-burning characteristics indicated, and lined with fire-retardant liner, **as directed**.
3. Wall Safety Pads: Padded wall wainscot panels designed to be attached in a continuous row; each panel section consisting of fill laminated to backer board with visible surfaces fully covered by seamless fabric covering, free of sag and wrinkles and firmly attached to back of backer board.
a. Backer Board: Not less than 3/8-inch- (9.5-mm-) thick plywood, mat formed, or composite panel **OR** fire-retardant-treated plywood per AWPA C27, Interior Type A, **as directed**.
b. Fill: Multiple-impact-resistant foam not less than 1-1/2-inch- (38-mm-) thick polyurethane, 3.5-lb/cu. ft. (56-kg/cu. m) density **OR** 2-inch- (50-mm-) thick polyurethane, 3.5-lb/cu. ft. (56-kg/cu. m) density **OR** 1-1/2-inch- (38-mm-) thick bonded polyurethane, 6.0-lb/cu. ft. (96-kg/cu. m) density **OR** 2-inch- (50-mm-) thick bonded polyurethane, 6.0-lb/cu. ft. (96-lb/cu. ft. (96-kg/cu. m) density **OR** 1-1/4-inch- (32-mm-) thick, closed-cell polyethylene, **as directed**.
c. Fire-Resistive Fill: Multiple-impact-resistant foam not less than 1-1/2-inch- (38-mm-) thick fire-resistive neoprene, 6.0-lb/cu. ft. (96-kg/cu. m) density **OR** 2-inch- (50-mm-) thick fire-resistive neoprene, 6.0-lb/cu. ft. (96-kg/cu. m) density, **as directed**.
d. Size: Each panel section, 24 inches (600 mm) wide by not less than 60 inches (1520 mm) long **OR** 24 inches (600 mm) wide by not less than 72 inches (1800 mm) long **OR** manufacturer's standard dimensions **OR** as indicated, **as directed**.
e. Number of Panel Sections: As indicated on Drawings **OR as directed,** modular panel sections.
f. Installation Method: Concealed mounting Z-clips **OR** Concealed mounting Z-clips and 1-inch (25-mm) bottom fabric attachment flange with exposed fasteners **OR** 1-inch (25-mm) top and bottom fabric attachment flange with exposed fasteners **OR** Manufacturer's standard, **as directed**.
g. Fabric Covering Color(s): Match school colors **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**, for one **OR** two, **as directed**, color(s).
h. Graphics: Custom graphics as indicated.

4. Corner Wall Safety Pads: Wall corner pad consisting of not less than 1-1/4-inch- (32-mm-) thick, multiple-impact-resistant, closed-cell polyethylene-foam filler, covered on both sides and all edges by fabric covering with backer board and manufacturer's standard anchorage to wall **OR** self-adhesive, hook-and-loop attachment to exposed face of wall, **as directed**.
   a. Length: Each pad not less than 72 inches (1800 mm) **OR** in manufacturer's standard length **OR** matching length of wall safety pads **OR** as indicated, **as directed**.
   b. Fabric Covering Color(s): Match color of wall safety pads **OR** Match school colors **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**, for one **OR** two, **as directed**, color(s).
5. Column Safety Pads: Pads covering exposed flange of columns to height indicated, consisting of not less than 1-1/4-inch- (32-mm-) thick, multiple-impact-resistant, closed-cell polyethylene-foam filler, covered on both sides and all edges by fabric covering with backer board and manufacturer's standard anchorage to column **OR** self-adhesive, hook-and-loop attachment to exposed face of column, **as directed**.
   a. Length: Each pad not less than 72 inches (1800 mm) **OR** in manufacturer's standard length **OR** matching length of wall safety pads **OR** as indicated, **as directed**.
   b. Fabric Covering Color(s): Match color of wall safety pads **OR** Match school colors **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**, for one **OR** two, **as directed**, color(s).
6. Round Column Safety Pads: Wraparound pads fully **OR** partially, **as directed**, covering exposed round column to height indicated, consisting of not less than 2-inch- (50-mm-) thick, multiple-impact-resistant, bonded polyurethane-foam filler, 6.0-lb/cu. ft (96-kg/cu. m) density, covered on both sides and all edges by fabric covering with hook-and-loop **OR** cord lace and grommet, **as directed**, attachment to column.
   a. Length: Each pad not less than 72 inches (1800 mm) **OR** in manufacturer's standard length **OR** as indicated, **as directed**.
   b. Fabric Covering Color(s): Match color of wall safety pads **OR** Match school colors **OR** As indicated by manufacturer's designations **OR** Match samples **OR** As selected from manufacturer's full range, **as directed**, for one **OR** two, **as directed**, color(s).

1.3 EXECUTION

A. Installation, General
1. General: Comply with manufacturer's written installation instructions and competition rules indicated for each type of gymnasium equipment, **as directed**. Complete equipment field assembly, where required.
2. Unless otherwise indicated, install gymnasium equipment after other finishing operations, including painting, have been completed.
3. Permanently Placed Gymnasium Equipment and Components: Rigid, level, plumb, square, and true; anchored securely to supporting structure; positioned at locations and elevations indicated on Shop Drawings; in proper relation to adjacent construction; and aligned with court layout.
   a. Floor Insert Location: Coordinate location with application of game lines and markers, and core drill floor for inserts after game lines have been applied, **as directed**.
   b. Floor Insert Elevation: Coordinate installed heights of floor insert with installation and field finishing, **as directed**, of finish flooring and type of floor plate.
   c. Operating Gymnasium Equipment: Verify clearances for movable components of gymnasium equipment throughout entire range of operation and for access to operating components.
4. Floor Insert Setting: Position sleeve in oversized, recessed voids in concrete slabs and footings. Clean voids of debris. Fill void around sleeves with grout, mixed and placed to comply with grout manufacturer's written instructions. Protect portion of sleeve above subfloor and footing, **as directed**, from splatter. Verify that sleeves are set plumb, aligned, and at correct height and spacing; hold in position during placement and finishing operations until grout is sufficiently cured. Set insert so top surface of completed unit is flush with finished flooring surface.

5. Wall **OR** Corner **OR** Column, **as directed**, Safety Pads: Mount with bottom edge at 4 inches (102 mm) **OR** dimension indicated on Drawings, **as directed**, above finished floor.
6. Anchoring to In-Place Construction: Use anchors and fasteners where necessary for securing built-in and permanently placed gymnasium equipment to structural support and for properly transferring load to in-place construction.
7. Connections: Connect automatic operators to building electrical system.
8. Removable Gymnasium Equipment and Components: Assemble in place to verify that equipment and components are complete and in proper working order. Instruct Owner's designated personnel in properly handling, assembling, adjusting, disassembling, transporting, storing, and maintaining units. Disassemble removable gymnasium equipment after assembled configuration has been approved by the Owner **OR** Owner, **as directed**, and store units in location indicated on Drawings.

B. Adjusting
1. Adjust movable components of gymnasium equipment to operate safely, smoothly, easily, and quietly, free from binding, warp, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Lubricate hardware and moving parts.

C. Cleaning
1. After completing gymnasium equipment installation, inspect components. Remove spots, dirt, and debris and touch up damaged shop-applied finishes according to manufacturer's written instructions.
2. Replace gymnasium equipment and finishes that cannot be cleaned and repaired, in a manner approved by the Owner, before time of Substantial Completion.

END OF SECTION 11481

SECTION 11481a - GYMNASIUM DIVIDERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for gymnasium dividers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes gymnasium divider curtains.

C. Submittals
1. Product Data: For each type of product indicated.
   a. If applicable, include assembly, disassembly, and storage instructions for removable equipment.
   b. Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
3. Structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation including loads, point reactions, and locations for attachment of gymnasium dividers to structure.
4. Samples: For each type of gymnasium divider curtain fabric indicated.
5. Operation and maintenance data.
6. Warranty.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of gymnasium dividers that fail in materials or workmanship within five **OR** 10, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Materials
1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
   a. Extruded Bars, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
   b. Cast Aluminum: ASTM B 179.
   c. Flat Sheet: ASTM B 209 (ASTM B 209M).
2. Steel: Comply with the following:
   a. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
   b. Steel Tubing: ASTM A 500 or ASTM A 513, cold formed.
   c. Steel Sheet: ASTM A 1011/A 1011M.
3. Support Cable: 1/4-inch- (6-mm-) diameter, 7x19 **OR** Manufacturer's standard, **as directed**, galvanized steel aircraft cable with a breaking strength of 7000 lb (3175 kg), **as directed**. Provide fittings complying with cable manufacturer's written instructions for size, number, and method of installation.

4. Support Chain and Fittings: Grade 80 hardened alloy steel chain rated for overhead lifting, ASTM A 391/A 391M, with commercial-quality, hot-dip galvanized **OR** zinc-plated, **as directed**, steel connectors and hangars.
5. Castings and Hangers: Malleable iron, ASTM A 47/A 47M, grade required for structural loading.
6. Anchors, Fasteners, Fittings and Hardware: Manufacturer's standard corrosion-resistant or noncorrodible units; concealed; tamperproof, vandal- and theft-resistant design, **as directed**.

B. Divider Curtains
1. Divider Curtains: Electrically **OR** Manually, **as directed**, operated, fold up **OR** roll up **OR** walk draw, **as directed**, and as follows:
   a. Upper, **as directed**, Curtain, Mesh: Woven fabric of 100 percent polyester yarn coated with PVC weighing not less than 6.5 oz./sq. yd (220 g/sq. m).
      1) Mesh Color: White **OR** Yellow, **as directed**.
   b. Lower, **as directed**, Curtain, Solid: Woven polyester coated with PVC, 18 oz./sq. yd (610 g/sq. m), embossed, 8-foot (2.4-m) **OR** 10-foot (3.0-m), **as directed**, height above floor.
      1) Fabric Color(s): Match school colors **OR** As selected from manufacturer's full range, **as directed**, for one **OR** two, **as directed**, color(s).
   c. Divider Curtain Flame-Resistance Ratings: Passes NFPA 701, inherently and permanently flame resistant.
      1) Permanently attach label to each fabric of curtain assembly indicating whether fabric is inherently and permanently flame resistant or treated with flame-retardant chemicals, and whether it will require retreatment after designated time period or cleaning.
2. Curtain Fabrication: Fused seams and the following:
   a. Top Hem: Reinforce with double thickness mesh for grommets **OR** continuous pipe batten, **as directed**.
   b. Bottom Hem for Fold-up Curtains: Floor-length curtains with hems 2 inches (50 mm) above finished floor and with manufacturer's standard pipe batten with felt padding in pocket.
   c. Bottom Hem for Roll-up Curtains: Floor-length curtains with hems 2 inches (50 mm) above finished floor and with manufacturer's standard 3-1/2- to 4-inch- (89- to 102-mm) roll-up tube and lifting tape.
   d. Bottom Hem for Draw Curtains: Floor-length curtains with hems 2 inches (50 mm) above finished floor with proof coil chain in pocket.
3. Accessories:
   a. Grommets: Manufacturer's standard size and spacing, for snaps or S-hooks.
   b. Proof Coil Chain: Grade 30, No. 8, zinc plated, 3/16 inch (4.7 mm), ASTM A 413/A 413M.
   c. Curtain Battens: Fabricate battens from steel pipe with a minimum number of joints. As necessary for required lengths, connect pipe with drive-fit pipe sleeve not less than 18 inches (450 mm) long, and secure with 4 flush rivets, plug welds, threaded couplings, or another equally secure method. Shop-paint completed pipe battens with black paint.
      1) Steel Pipe: ASTM A 53/ A 53M, Grade A, standard weight (Schedule 40), black, 1-1/2-inch (40-mm) nominal diameter, unless otherwise indicated.
4. Divider Curtain Operator: Roll-up drive tube **OR** Upward folding, cable suspended **OR** Walk-draw cable with pulleys **OR** Walk-draw track, **as directed**.
5. Divider Curtain Electric Operator: Provide operating machine of size and capacity recommended by manufacturer for equipment specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, and remote controls. Coordinate wiring requirements and electrical characteristics with building electrical system.
   a. Operator Type: Electric motor, belt-reduction **OR** enclosed gear-head-reduction **OR** worm-gear running-in-oil, **as directed**, drive, with chain and sprocket secondary drive.
   b. Motor Characteristics: Sufficient to start, accelerate, reverse, and operate connected loads at designated speeds within installed environment and with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1, and the following:

1) Voltage: 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.
2) Horsepower: 3/4 **OR** 1, **as directed**, hp.
3) Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
4) Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
5) Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
6) Phase: One.

c. Remote-Control Station(s): NEMA ICS 6, Type 1 enclosure for surface **OR** recessed or flush, **as directed**, mounting, momentary-contact, three-position switch-operated control.
1) Keys: Provide one **OR** two, **as directed**, key(s) per station.

1.3 EXECUTION

A. Installation, General
1. General: Comply with manufacturer's written installation instructions. Complete field assembly, where required.
2. Unless otherwise indicated, install gymnasium dividers after other finishing operations, including painting, have been completed.
3. Gymnasium Dividers and Components: Rigid, level, plumb, square, and true; anchored securely to supporting structure; positioned at locations and elevations indicated on Shop Drawings; in proper relation to adjacent construction; and aligned with court layout.
a. Verify clearances for movable components of gymnasium dividers throughout entire range of operation and for access to operating components.
4. Anchoring to In-Place Construction: Use anchors and fasteners where necessary for securing gymnasium dividers to structural support and for properly transferring load to in-place construction.
5. Connections: Connect automatic operators to building electrical system.

B. Adjusting
1. Adjust movable components of gymnasium dividers to operate safely, smoothly, easily, and quietly, free from binding, warp, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Lubricate hardware and moving parts.

C. Cleaning
1. After completing gymnasium divider installation, inspect components. Remove spots, dirt, and debris and touch up damaged shop-applied finishes according to manufacturer's written instructions.
2. Replace gymnasium divider components and finishes that cannot be cleaned and repaired, in a manner approved, before time of Substantial Completion.

END OF SECTION 11481a

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SECTION 11910 - RESIDENTIAL APPLIANCES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for residential appliances. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Cooking equipment including:
1) Electric cooktops.
2) Gas cooktops.
3) Electric ranges.
4) Gas ranges.
5) Dual fuel ranges.
6) Electric wall ovens.
7) Gas wall ovens.
8) Microwave ovens.
b. Ventilation range hoods and downdraft system.
c. Refrigerator/freezers.
d. Freezers.
e. Icemakers.
f. Cleaning appliances:
1) Dishwashers.
2) Clothes washers.
3) Clothes dryers.
4) Combination clothes washer and dryer.
g. Trash compactors.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Credit EA 1.4: For appliances, documentation indicating that products are ENERGY STAR rated.
3. Samples: For each exposed finish.
4. Appliance Schedule: For appliances; use same designations indicated on Drawings.
5. Maintenance data.
6. Warranties: Special warranties specified in this Section.

D. Quality Assurance
1. Installer Qualifications: An employer of workers trained and approved by manufacturer for installation and maintenance of units required for this Project.
2. Regulatory Requirements: Comply with provisions of the following product certifications:
a. NFPA: Provide electrical appliances listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
b. UL and NEMA: Provide electrical components required as part of residential appliances that are listed and labeled by UL and that comply with applicable NEMA standards.
c. ANSI: Provide gas-burning appliances that comply with ANSI Z21 Series standards.
d. NAECA: Provide residential appliances that comply with NAECA standards.

3. Regulatory Requirements, Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ANSI A117.1 **OR** FED-STD-795, "Uniform Federal Accessibility Standards," **as directed**.
   a. Operable Parts: Provide controls with forward reach no higher than 48 inches (1219 mm) above the floor, horizontal front reach no more than 25 inches (635 mm), horizontal side reach no more than 24 inches (610 mm), and that do not require tight grasping, pinching, or twisting of the wrist and that operate with a force of not more than 5 lbf (22.2 N).
   b. Range or Cooktop: Provide knee clearance for forward approach of 27 inches (685 mm) high, 30 inches (760 mm) wide, and 11 inches (280 mm) horizontally; toe space clearance of 9 inches (230 mm) high and 17 inches (430 mm) horizontally; with insulated underside of cooktop to prevent burns, shocks, or abrasions. Provide top surface 34 inches (865 mm) above the floor, with controls that do not require reaching across burners.
   c. Refrigerator/Freezer: Provide 50 percent of freezer space within 54 inches (1370 mm) of the floor.
4. AHAM Standards: Provide appliances that comply with the following AHAM standards:
   a. Dishwashers: AHAM DW-DW1.
   b. Electric Ranges: AHAM ER-1.
   c. Clothes Dryers: AHAM HLD-1.
   d. Household Refrigerators: AHAM HRF-1.
   e. Household Freezers: AHAM HRF-1.
   f. Trash Compactors: AHAM TC-1.
5. Energy Ratings: Provide residential appliances that carry labels indicating energy-cost analysis (estimated annual operating costs) and efficiency information as required by the FTC Appliance Labeling Rule.
   a. Provide appliances that qualify for the EPA/DOE ENERGY STAR product labeling program.
6. Preinstallation Conference: Conduct conference at Project site.

E. Warranty
1. Special Warranties: Manufacturer's standard form in which manufacturer of each appliance specified agrees to repair or replace residential appliances or components that fail in materials or workmanship within specified warranty period.
   a. Electric Range: Five-year limited warranty for in-home service on surface-burner elements.
   b. Microwave Oven: Five-year limited warranty for in-home service on defects in the magnetron tube.
   c. Refrigerator/Freezer: Five-year limited warranty for in-home service on the sealed refrigeration system.
   d. Freezer: Five-year limited warranty for in-home service on the sealed refrigeration system.
   e. Dishwasher: 10-year warranty for in-home service against deterioration of tub and door liner.
   f. Clothes Washer: 10-year limited warranty for in-home service on the inner wash basket and outer tub, and five-year limited warranty for in-home service on the balance suspension system and drive transmission.

1.2 PRODUCTS

A. Cooking Appliances
1. Cooktop:
   a. Electric Cooktop:
      1) Two **OR** Four **OR** Six, **as directed**, electric burner elements.
         a) Coil Type **OR** Radiant Type, **as directed**.

2) Size: 12 inches (300 mm) **OR** 30 inches (760 mm) **OR** 36 inches (915 mm), **as directed**.
3) Finish: Porcelain-enamel steel **OR** Ceramic glass **OR** glass **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.

b. Gas Cooktop: Two **OR** Four **OR** Six, **as directed**, gas burners.
1) Size: 12 inches (300 mm) **OR** 30 inches (760 mm) **OR** 36 inches (915 mm), **as directed**.
2) Finish: Porcelain-enamel steel **OR** Ceramic glass **OR** glass **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.

c. Downdraft Ventilation: Manufacturer's standard **OR** 550 cfm (260 L/s), **as directed**, with remote, **as directed**, blower and exterior weatherproof wall cap.

d. Accessories: Grill **OR** Wok ring, **as directed**.

2. Range:

a. Freestanding **OR** Drop-in, **as directed**, Electric Range:
1) Size: 30 inch (760 mm) **OR** 36 inch (910 mm), **as directed**.
2) Electric Burner Elements: Four **OR** Six, **as directed**.
a) Coil Type **OR** Radiant Type, **as directed**.
3) Oven(s): One **OR** Two, **as directed**.
a) Oven Performance: Baking **OR** Convection, **as directed**, and self-cleaning, **as directed**.
4) Finish: Porcelain-enamel **OR** Stainless, **as directed**, steel with glass **OR** ceramic-glass **OR** manufacturer's standard, **as directed**, cooktop.

b. Freestanding **OR** Drop-in, **as directed**, Gas Range:
1) Size: 30 inch (760 mm) **OR** 36 inch (910 mm), **as directed**.
2) Gas Burners: Four **OR** Six, **as directed**.
3) Oven(s): One **OR** Two, **as directed**.
a) Oven Performance: Baking **OR** Convection, **as directed**, and self-cleaning, **as directed**, with 25,000-Btu (26 376-kJ) burner, **as directed**.
4) Finish: Porcelain-enamel **OR** Stainless, **as directed**, steel with glass **OR** manufacturer's standard, **as directed**, cooktop.

c. Freestanding **OR** Drop-in, **as directed**, Dual Fuel Range:
1) Size: 30 inch (760 mm) **OR** 36 inch (910 mm), **as directed**.
2) Gas Burners: Four **OR** Six, **as directed**.
3) Oven Performance: Baking **OR** Convection, **as directed**, and self-cleaning, **as directed**.
4) Finish: Porcelain-enamel **OR** Stainless, **as directed**, steel with glass **OR** manufacturer's standard, **as directed**, cooktop.

3. Wall Oven:

a. Electric Wall Oven(s): One **OR** Two, **as directed**; standard features include the following:
1) Oven Performance: Baking **OR** Convection, **as directed**, Self-cleaning, **as directed**, with broiler, **as directed**.
2) Finish: Porcelain-enamel steel **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.

b. Gas Wall Oven(s): One **OR** Two, **as directed**, standard features include the following:
1) Oven Performance: Baking **OR** Convection, **as directed**, Self-cleaning, **as directed**, with broiler, **as directed**.
2) Finish: Porcelain-enamel steel **OR** Stainless steel **OR** Manufacturer's standard, **as directed**.

4. Microwave Oven:

a. Oven(s): Standard features include the following:
1) Oven Capacity: 1.5 cu. ft. (0.04 cu m).
2) Exhaust Fan: Variable-speed **OR** Two-speed **OR** Four-speed, **as directed**, fan, convertible **OR** vented to outside **OR** nonvented, recirculating-type with charcoal filter, **as directed**, 300 cfm (140 L/s), **as directed**.

5. Exhaust Hood:

a. Type: 30-inch (762-mm) **OR** 36-inch (914-mm), **as directed**, wall-mounted **OR** suspended-island-canopy **OR** retractable-downdraft **OR** undercabinet **OR** slide-out, ventilating **OR** nonvented, recirculating **OR** convertible, **as directed**, range hood.
b. Exhaust Fan: Variable-speed **OR** Two-speed **OR** Three-speed, **as directed**, fan, 550 cfm (260 L/s), built-in hood **OR** remote ventilator fan and housing, **as directed**.
c. Finish: Baked enamel **OR** Stainless steel, **as directed**.

B. Refrigeration Appliances
1. Refrigerator/Freezer:
a. Type: Freestanding **OR** Built into cabinet **OR** Under the counter, **as directed**, frost-free **OR** cycle-defrost, **as directed**, two-door freezer **OR** one-door refrigerator with inside freezer compartment **OR** side-by-side refrigerator/freezer, **as directed**, with freezer on top **OR** with freezer on bottom, **as directed**.
b. Storage Capacity:
1) Fresh Food Compartment Volume: 15.6 cu. ft. (0.44 cu. m).
2) Freezer Volume: 5.13 cu. ft. (0.15 cu. m).
c. Front Panel: Wood-panel door front and lower access panel to match kitchen cabinets **OR** Stainless-steel door front and lower access panel **OR** Manufacturer's standard **OR** Reversible panels with choice of colors for door front and lower access panel, **as directed**.
2. Freezer:
a. Type: Freestanding, frost free **OR** manual defrost, **as directed**, upright **OR** chest type, **as directed**.
b. Storage Capacity:
1) Freezer Volume: 5.13 cu. ft. (0.15 cu. m) **OR** 15.0 cu. ft. (0.425 cu. m), **as directed**.
c. Appliance Color: White.
3. Icemaker:
a. Type: Under the counter **OR** Freestanding, **as directed**.
b. Ice Capacity:
1) Production: 30 lb (13.6 kg) per day.
2) Storage: 26 lb (11.8 kg).
c. Front Panel: Wood-panel door front and lower access panel to match kitchen cabinets **OR** Stainless-steel door front and lower access panel **OR** Manufacturer's standard **OR** Reversible panels with choice of colors for door front and lower access panel, **as directed**.

C. Cleaning Appliances
1. Dishwasher:
a. Type: Portable **OR** Convertible **OR** Under the counter **OR** Under the sink/cooktop, **as directed**, 24 inches (610 mm) **OR** 18 inches (460 mm), **as directed**, wide, operable at water pressures from 15 to 120 psi (100 to 825 kPa).
b. Front Panel: Wood-panel door front and lower access panel to match kitchen cabinets **OR** Stainless-steel door front and lower access panel **OR** Manufacturer's standard **OR** Reversible panels with choice of colors for door front and lower access panel, **as directed**.
2. Clothes Washer:
a. Type: Freestanding, stacking, **as directed**, top **OR** front, **as directed**, loading, operable at water pressures from 15 to 120 psi (100 to 825 kPa).
b. Finish: Porcelain enamel on top and lid. Baked enamel on front and sides.
3. Clothes Dryer:
a. Type: Freestanding **OR** Stacking, **as directed**, gas **OR** electric, **as directed**.
b. Finish: Porcelain enamel on top and lid; baked enamel on front and sides.
4. Combination Clothes Washer and Dryer:
a. Type: Freestanding washer with integral gas **OR** electric, **as directed**, dryer, 24 inches (610 mm) **OR** 27 inches (685 mm), **as directed**, wide.
b. Finish: Porcelain enamel on top and lid; baked enamel on front and sides.
c. Color: White **OR** Almond, **as directed**.
5. Trash Compactor:

a. Type: Convertible **OR** Built-in, **as directed**.
b. Capacity: 1.4 cu. ft. (0.04 cu. m).
c. Cabinet Front: 1/4-inch- (6-mm-) thick wood panel to match kitchen cabinets **OR** Enameled steel **OR** Stainless steel, **as directed**.

D. Finishes, General
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Color-Coated **OR** Stainless-Steel, **as directed**, Finish: Provide appliances with manufacturer's standard finish complying with manufacturer's written instructions for surface preparation including pretreatment, application, baking, color, gloss, and minimum dry film thickness for painted finishes **OR** ground and polished stainless-steel surfaces for uniform, directionally textured finish, **as directed**.

1.3 EXECUTION

A. Installation, General
1. General: Comply with manufacturer's written instructions.
2. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and rough openings are completely concealed.
3. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
4. Utilities: Refer to Division 14 AND Division 15 for plumbing and electrical requirements.

B. Cleaning And Protection
1. Test each item of residential appliances to verify proper operation. Make necessary adjustments.
2. Verify that accessories required have been furnished and installed.
3. Remove packing material from residential appliances and leave units in clean condition, ready for operation.

END OF SECTION 11910

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SECTION 11910a - REFRIGERATORS

1.1 GENERAL

A. Summary
1. Section Includes:
a. Remove existing refrigerators.
b. Refrigerators supply and deliver only or supply and install as scheduled.
2. Related Requirements: Comply with requirements of following sections:
a. Contractor Use of Premises and Work Sequence
b. Section “Alteration Project Procedures.”
3. Related Sections:
a. Kitchen Renovation Requirements; “Summary of Work”
b. Reference Standards: Section “References.”

B. References
1. Reference Standards: See Section “References.” Comply with following:
a. Association of Home Appliance Manufacturers (AHAM) HRF-1 - Standard for Household Refrigerators and Household Freezers, 1988.
1) ASTM B 117 - Salt Spray (Fog) Testing.
b. ANSI/UL 250 - Household Refrigerators and Freezers, 1991.
c. Certification:
1) ANSI Z34.2 - Certification, Self-Certification by Producer or Supplier, 1987.

C. Definitions
1. Configurations:
a. SD: Single Door.
b. TF: Top Freezer.
c. BF: Bottom Freezer.
d. SS: Side-by-Side.
2. Defrost System:
a. M: Manual Defrost: Defrost system in which defrosting action for refrigerated surfaces is initiated manually.
b. P: Partial Automatic: Defrost system in which defrosting action for refrigerated surfaces in refrigerator compartment is initiated and terminated automatically and defrosting action for refrigerated surfaces in freezer is initiated manually.
c. A: Automatic Defrost: Defrost system in which defrosting action for all refrigerated surfaces is initiated and terminated automatically.
3. Efficiency Standards:
a. Refrigerator: Cabinet designed for refrigerated storage of food at temperatures above 0 degrees C (32 degrees F) and may include compartment for freezing and storage of food at temperatures below 0 degrees C (32 degrees F), but does not provide separate low temperature compartment designed for freezing and storage of food at temperatures below minus 13 degrees C (8 degrees F).
b. Refrigerator-freezer: Cabinet with two or more compartments with at least one compartment designed for refrigerated storage of food at temperatures above 0 degrees C (32 degrees F) and with at least one compartment designed for freezing and storage of food at temperatures below minus 13 degrees C (8 degrees F).
c. AV: Adjusted Volume:
1) Refrigerator: [1.44 x freezer volume (cubic feet)] + refrigerator volume (cubic feet).
2) Refrigerator-freezer: [1.63 x freezer volume (cubic feet)] + refrigerator volume (cubic feet).
4. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by PHA/IHA.

D. System Description
1. Performance Requirements: Comply with following:
a. Refrigerators: Capable of producing average cabinet air temperature in general food storage compartment of 2.2 degrees C (36 degrees F) in ambient of 21.1 degrees C (70 degrees F), and 3.3 degrees C (38 degrees F) in ambient of 43.3 degrees C (110 degrees F).
1) Performance Test Procedures: As specified in AHAM HRF-1.
b. Plastic Compartment and Door Liners: Not show any cracks or crazing when tested under Environment Cracking Resistance Test specified in AHAM HRF-1.
1) Single-Piece Liners Testing: As specified in AHAM HRF-1, paragraph 10.6.
2. Efficiency Standards: Provide refrigerators which do not exceed following annual energy consumption in kWh:
a. Refrigerators and Refrigerator-freezers with Manual Defrost: 13.5 AV plus 299.
b. Refrigerator-freezers with Partial Automatic Defrost: 10.4 AV plus 398.
c. Refrigerator-freezers with Automatic Defrost with Top Mounted Freezer without Through-the-door Ice Service: 16.0 AV plus 355.
d. Refrigerator-freezers with Automatic Defrost with Side Mounted Freezer without Through-the-door Ice Service: 11.8 AV plus 501.
e. Refrigerator-freezers with Automatic Defrost with Bottom Mounted Freezer without Through-the-door Ice Service: 16.5 AV plus 367.

E. Submittal
1. Product Data: Submit to Contracting Officer.
2. Samples:
a. Production Sample: When requested, provide sample refrigerator to Contracting Officer for examination as to compliance with specifications.
b. Color Samples: Submit samples of manufacturer s standard colors to Contracting Officer for selection.
3. Quality Assurance/Control Submittals: Submit following to Contracting Officer:
a. Certificates: Manufacturer's written self certification that refrigerators meet or exceed specified requirements.
b. Manufacturer's installation instructions.
4. Closeout Submittals: Submit following to Contracting Officer:
a. Operation and Maintenance: Provide use and care information with each refrigerator. Include parts manual with diagrams and part numbers.
b. Special warranty.

F. Quality Assurance
1. Qualifications: Manufacturer: Stock and sell parts for refrigerators supplied for five years from time of delivery.
2. Regulatory Requirements: Comply with following:
a. EPA regulations regarding refrigerant.
b. Accessibility:
1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
a) Uniform Federal Accessibility Standards (UFAS).
2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
3. Appliances shall meet or exceed requirements established by the Energy Star program and bear the Energy Star logo. Visit www.energystar.gov for a listing of products that qualify. Energy Star® is a voluntary partnership that includes the U.S. Department of Energy, the U.S. Environmental Protection Agency, product manufacturers, local utilities, and retailers, helps

promote efficient products by labeling them with the Energy Star logo and educating consumers about the benefits of energy efficiency.

G. Delivery, Storage, And Handling
1. Packing, Shipping, Handling, and Unloading: In accordance with standard commercial practices.
2. Acceptance at Site: Inspect refrigerators upon delivery. Replace damaged or defective appliances before installation.

H. Scheduling
1. Scheduling and Completion: Comply with requirements of Division 1.

I. Warranty
1. Special Warranties: Provide following written special warranties:
   a. Plastic parts of cabinet for period of two years.
   b. Sealed refrigerator cooling system for five years.
      1) Provide new or reconditioned cooling system units or components, replacing units and/or parts which become defective (excluding damage due to visible abuse) during five year period.
   c. Entire refrigerator for one year.
2. Special Warranty Periods: If refrigerator becomes inoperative, as defined in following paragraph, repair or replace and install any part (except enamel, porcelain or lacquer) necessary to make refrigerator operative within five working days of notification.
   a. Inoperative Refrigerator: When interior cabinet temperature rises above 10.0 degrees C (50 degrees F) and remains at such temperature for six or more consecutive hours after usual normal adjustments have been made or other mechanical and electrical trouble affecting normal operations has been corrected.
3. Special Warranties: Include labor, material and equipment to provide replacements and make repairs to refrigerators at no additional cost to PHA/IHA.
   a. Defective Units and/or Parts: Become property of Contractor.
   b. Submit name and address of local agent who will furnish service and replacement parts in connection with warranties to PHA/IHA.
      1) Charges by local service agent to PHA/IHA for services covered under special warranties not allowed.

1.2 PRODUCT

A. Refrigerators - General Requirements
1. Refrigerators: Household type, self-contained with electric-motor-driven condensing units and comply with Performance Requirements and Energy Standard Requirements.
2. Types, Sizes and Grades: As specified and scheduled.
3. Total Storage Volumes, Shelf Areas and Dimensions: In accordance with descriptions and computed in accordance with AHAM HRF-1.

B. Refrigerators Cabinets
1. Outer Shells (including Doors): Carbon-steel sheet finished in baked synthetic enamel.
   a. Colors: As scheduled from manufacturer s standard colors.
2. Exterior Doors: Provide with reversible hinges for right or left hand swing except on side-by-side (SS) configuration.
   a. Construction of Freezer or Evaporator Door and Hinging: Door may be operated without breaking, cracking, or distorting when freezer or evaporator is free from or has maximum thickness of 6 mm (1/4 inch) of frost on outer surface of evaporator adjacent to door.
   b. Exterior Doors: Equipped with magnetic gasket.
   c. Doors: Contain shelves.
3. Interior Liners of (including General and Low-Temperature) Storage Compartments and Doors: Porcelain enamel on carbon-steel or molded plastic.

a. Carbon-Steel Sheet Inner Liners: Porcelain enamel or baked synthetic enamel finish.
b. Color of Plastic Inner Liners: White or pastel.
c. Plastic Liners in Conjunction with Foamed-In-Place Polyurethane Employing Fluorinated Hydrocarbons: Isolate liner material from polyurethane foam or fabricate of acrylonitrile butadiene styrene (ABS) or High Impact Polystyrene (HIPS).
d. Breaker Strips: ABS plastic, polypropylene, or HIPS when insulation is foamed-in-place polyurethane with fluorinated hydrocarbons.

4. Drawers and Trays:
   a. Vegetable Drawers or Crisper Trays: Provide one or more trays occupying full width of food compartment and readily removable.
   b. Drawers or Trays: Constructed of steel finished with porcelain enamel, anodized aluminum, or durable plastic; durable glass; or non-corrosive metal.
   c. Ice Cube Trays: Provide minimum of two standard size ice cube trays.
   d. Defrosting or Chiller Tray: Made of material suitable for intended service and of adequate size to receive drip from cooling unit during defrosting.
5. Hardware Components: Sturdy construction and made of material that are durable and structurally correct for application.
   a. Hardware Attachment Devices (screws, bolts and nuts): Of material and finish consistent with material of components and parts which they are used.
   b. Hardware Finish: Remain intact after being subjected to salt spray test for period of 25 hours in accordance with ASTM B 117.
      1) Center Section of Door Handle: Vinyl covered steel is acceptable.
   c. Food Compartment Door Hinges: May be same finish as specified for outer panel of food compartment door.
   d. Hardware: Securely attached in substantial manner and to extent that removal may not be accomplished without use of tools.
6. Manual Defrost and Partial Defrost Refrigerators: Provide clear and legible caution similar to following: Do not use implements to defrost or to remove ice trays or other material from freezer section.
   a. Location: Print or impress on freezer door or on name plate securely fastened in another prominent position easily read by user.

C. Refrigerators Components
1. Electrical Components and Parts: Locate and mount controls, lamp socket, relay, switches, thermostat, wiring harness, cables and leads and their accessories in manner that their replacement may be readily accomplished.
   a. Electrical Assemblies and Harness: Design and manufacture so that replacement of complete assembly or harness is not necessary when any component part of assembly becomes defective or inoperative.
   b. Individual Components and Parts of Assemblies and Harness: Obtainable for relatively simple replacement purposes.
2. Temperature Control: Equip refrigerators with off position and contact points or setting positions for wide range of degrees of temperature, which may be selected by readily accessible knob, properly marked with settings available, mounted on temperature control shaft.
   a. Relay: Quality and rating which under normal operating conditions shall function properly for at least one year period and which is consistent with requirements specified and its companion components and parts in electrical circuit.
3. Motor: For 115 volt, plus or minus 10 percent, 60 HZ, single phase, alternating current operation and capable of starting in ambient temperature of 37.8 degrees C (100 degrees F) on voltages between 90 percent and 100 percent of rated voltage.
   a. Thermal Overload Protection: Automatic re-set type to prevent excess temperature rise of motor windings.
   b. Three-Wire Cord with Three-Prong Attachment Plug: Provide grounding of refrigerator and extend five feet to nine feet beyond point at which it is attached to back of cabinet.

c. Motor: Type, speed, load and horsepower ratings consistent with other requirements specified.

4. Refrigeration Unit: Compressor, motor and housing of hermetically sealed type with reciprocating or rotary-type compressor.
   a. Compressor: Equipped with means of unloading, such as automatic unloader or capillary tube.
   b. Sealed Refrigerating System: Serviceable by complete unit replacement or replacement of component parts such as motor compressor assembly, evaporator, condenser and heat exchanger.
   c. Hermetic Compressor Unit: Quiet in operation, free from excessive vibration and entirely automatic in operation.

D. Workmanship
1. Welding and Brazing: Complete; uniform and properly fused; with no holes, slag inclusions, scale, or flux deposits; and not cracked, fractured or undercut.
2. Soldering: Complete, clean, adherent and without pin-holes.
3. Fasteners: Not be broken, fractured, stripped, or loose.
   a. Structural Parts Subject to Vibration: Provide lock washers or self-locking washers.

1.3 EXECUTION

A. Examination
1. Site Verification of Conditions:
   a. Utilities: Verify that required utilities are available, in proper locations, and ready for use.

B. Preparation
1. Existing Refrigerators: Remove existing refrigerators and debris from site.

C. Installation
1. General: Install refrigerators in accordance with manufacturer's recommendations.
   a. Make adjustments to feet of refrigerators for a level installation.
   b. Install in manner to ensure proper ventilation space is present.

D. Cleaning
1. Cleaning: Comply with requirements of Section 01120.

E. Schedules
1. Provide refrigerators as selected in following schedule:

_____ Remove existing refrigerators.

_____ Supply and Deliver Only to_____.

_____ Unloading and handling included.

_____ Supply and Install.

SELECTION	SIZE	COLOR	TYPE
_____	0.28 cu m (10.0 CU FT) Minimum	_____	SD/M/S: Small, Single Door, Manual Defrost.
_____	0.37 cu m (13.0 CU FT) Minimum	_____	SD/M/L: Large, Single Door, Manual Defrost.
_____	0.28 - 0.34 cu m (10.0 - 11.9) CU FT	_____	TF/P/S: Small, Top Freezer, Partial Automatic Defrost.
_____	0.34 - 0.39 cu m (12.0 - 13.9 CU FT)	_____	TF/P/M: Medium, Top Freezer, Partial Automatic Defrost.

_____ 0.40 cu m (14.0 CU FT) Minimum	_____TF/P/L: Large, Top Freezer, Partial Automatic Defrost.
_____ 0.28 - 0.34 cu m (10.0 - 11.9 CU FT)	_____TF/A/S: Small, Top Freezer, Automatic Defrost.
_____ 0.34 - 0.39 cu m (12.0 - 13.9 CU FT)	_____TF/A/M: Medium, Top Freezer, Automatic Defrost.
_____ 0.40 - 0.45 cu m (14.0 - 15.9 CU FT)	_____TF/A/ML: Medium/Large, Top Freezer, Automatic Defrost.
_____ 0.45 - 0.51 cu m (16.0 - 17.9 CU FT)	_____TF/A/L: Large, Top Freezer, Automatic Defrost.
_____ 0.51 cu m (18.0 CU FT) Minimum	_____TF/A/EL: Extra Large, Top Freezer, Automatic Defrost.
_____ 0.45 cu m (16.0 CU FT) Minimum	_____BF/A for Accessible Units: Bottom Freezer, Automatic Defrost in accordance with UFAS requirements.
_____ 0.45 cu m (16.0 CU FT) Minimum	_____SS/A for Accessible Units: Side-by-Side, Automatic Defrost in accordance with UFAS requirements.

END OF SECTION11910a

SECTION 11910b - GAS RANGES

GENERAL

Summary

1. Section Includes:
   a. Remove existing ranges.
   b. Gas ranges, supply and deliver only or supply and install as scheduled.
2. Related Requirements: Comply with requirements of following sections:
   a. Contractor Use of Premises and Work Sequence; “Summary of Work”
   b. Section “Alteration Project Procedures.”
3. Related Sections:
   a. Kitchen Renovation Requirements: Section “Summary of Work”
   b. Reference Standards: Section “References.”
   c. Electric Ranges: Section “Electric Ranges.”
   d. Gas Line Relocation: Section “Plumbing.”

References

4. Reference Standards: See Section “References.” Comply with following:
   a. American National Standard Institute (ANSI) Z21.1 - Household Cooking Gas Appliances,1990, including addenda Z21.1a, 1991.
      1) ANSI Z21.20 - Automatic Gas Ignition Systems and Components, 1989, including addenda Z21.20a, 1991, and Z21.20b, 1992.
   b. Certification:
      1) ANSI Z34.1 - Certification, Third-Party Certification Program, 1987.
      2) ANSI Z34.2 - Certification, Self-Certification by Producer or Supplier, 1987.

Definitions

5. Types:
   a. Type A: Economy or Builder's Model
   b. Type C: Quality Model with hinged top.
6. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by PHA/IHA.

Submittals

7. Product Data: Submit to the Owner.
8. Samples:
   a. Production Sample: When requested, provide sample gas range to the Owner for examination as to compliance with specifications.
   b. Color Samples: Submit samples of manufacturer’s standard colors to the Owner for selection.
9. Quality Assurance/Control Submittals: Submit following to the Owner:
   a. Certificates: Manufacturer's written certification that ranges have been tested and comply with ANSI Z21.1 for operation with natural or LP gas.
      1) Certification by American Gas Association (AGA) Laboratories, or Third Party Certifier in accordance with ANSI Z34.1.
      2) Acceptable Evidence of Meeting Applicable Requirements of Standard: Photostatic copy of American Gas Association (AGA) Laboratories Appliance Certificate or listing including igniter device in American Gas Association (AGA) Laboratories Directory of Certified Appliances and Accessories.
   b. Manufacturer's installation instructions.

10. Closeout Submittals: Submit following to the Owner:

a. Operation and Maintenance: Provide use and care information with each gas range. Include parts manual with diagrams and part numbers.
b. Special warranty.

Quality Assurance

11. Qualifications: Manufacturer: Stock and sell parts for ranges supplied for five years from time of delivery.
12. Regulatory Requirements: Comply with and following:
    a. Gas Connections: Comply with applicable codes and regulations.
    b. Accessibility:
        1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
            a) Uniform Federal Accessibility Standards (UFAS).
        2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
        3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
        4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
13. Appliances shall meet or exceed requirements established by the Energy Star program and bear the Energy Star logo. Visit www.energystar.gov for a listing of products that qualify. Energy Star® is a voluntary partnership that includes the U.S. Department of Energy, the U.S. Environmental Protection Agency, product manufacturers, local utilities, and retailers, helps promote efficient products by labeling them with the Energy Star logo and educating consumers about the benefits of energy efficiency.

Delivery, Storage, And Handling

14. Packing, Shipping, Handling, and Unloading: In accordance with standard commercial practices.
15. Acceptance at Site: Inspect gas ranges upon delivery. Replace damaged or defective appliances before installation.

Scheduling

16. Scheduling and Completion: Comply with requirements of Division 1.

Warranty

17. Special Warranties: Provide following written special warranties:
    a. Entire gas range for one year.
18. Special Warranties: Include labor, material and equipment to provide replacements and make repairs to gas ranges at no additional cost to PHA/IHA.
    a. Defective Units and/or Parts: Become property of Contractor.
    b. Submit name and address of local agent who will furnish service and replacement parts in connection with warranties to PHA/IHA.
        1) Charges by local service agent to PHA/IHA for services covered under special warranties not allowed.

PRODUCTS

Gas Ranges - General Requirements

19. Ranges: ANSI Z21.1, current standard models of manufacturer except for additional requirements specified.
    a. Ranges: Floor mounted, free standing flush-to-wall, domestic gas ranges with open cooking top, oven and broiler below.
    b. Ranges of Same Size: Identical, including parts and assemblies.
20. Gas Valves: Provide with either:
    a. Convertible orifice set for gas specified on purchase order .
    b. Fixed orifice hood for use with gas specified on order.

21. Convertible Gas Pressure Regulators: Provide with each range.

Type A Ranges (Economy Or Builder S Model)

22. Burners: Provide cooking top with four burners.
    a. Each Burner: Rated at no less than 2 650 W (9000 BTU/H) for natural gas and 2 350 W (8000 BTU/H) for LP.
23. Manual Gas Valves: Limited displacement type complying with ANSI Z21.1.
24. Grates: Provide each top burner with porcelain enameled cast iron or steel grate.
25. Ignition: One of following:
    a. Automatic Ignition: Equip burners with means for automatic ignition of gas. Failure of oven burner pilot shall activate means for shutting off gas to oven burner.
    b. 2. Intermittent Ignition: Equip burners with means for automatic electric ignition of gas complying with applicable requirements of ANSI Z21.20. Electric Ignition System: May be either spark, coil, glow bar, or combination of these.
26. Oven Thermostat Control: Provide oven thermostat control for controlling oven temperatures down to "hold warm temperature", approximately 77 degrees C (170 degrees F).
27. F. Insulation: Glass fiber blanket type, installed in manner to prevent sagging, and of sufficient thermal efficiency to meet surface and handle temperature tests specified in ANSI Z21.1.
28. Oven and Broiler Sections: Porcelain enamel-coated steel.
    a. Broiling Section: Either drop door type, pull-out-type, or swing-door type with 3-position smokeless broiler pan and grill sliding on stationary runners.
    b. Provide stops so that oven racks cannot be completely pulled out by accident.
29. Oven Vents: Provide ovens with vent designed to deflect moisture and fumes away from wall behind range.
30. Oven Doors: Drop-shelf type, counter-balanced and provided with device to hold door fully closed.
    a. Hinges: Permit ready removal and replacement of hinge brackets and parts subject to wear.
    b. Provide oven doors with means for adjusting misaligned door.
31. Burner Bowls (Aeration Bowls): Corrosion-resisting steel, plated steel, or steel coated with porcelain enamel.
    a. Bowls: May be separate bowls or integral part of top.
32. Exterior Surfaces: Porcelain enamel, except body sides and front panels (including oven door) may be finished in synthetic baked-on enamel capable of withstanding 121 degrees C (250 degrees F).
    a. Trim: In accordance with manufacturer's standard practice.
    b. Backguard, Manifold Shield, Aeration Bowls, and Burners: May be porcelain enamel.
    c. Range Body Back Panel, Legs, and/or Base: Porcelain enamel, baked-on enamel, galvanized, or aluminized steel.
    d. Colors: As scheduled from manufacturer s standard colors.
33. Backguards: Equip each range with back guards not less than 100 mm (4 inches) higher than top cooking surface and extending full width of range top.
34. Equipment and Accessories: Provide accessories such as oven and broiler racks normally supplied with manufacturer's standard production for type range scheduled.
35. Name Plate: Permanent record of manufacturer's name and address, range model and serial number, and manufacturer's normal hourly W (BTU/H) input rating for oven, broiler and top burners.
    a. Securely fasten nameplate to main part of each range in accessible place.

Type C Ranges (Quality Model)

36. General Requirements: Comply with requirements for Type A Ranges except as modified by following requirements.
37. B. Range Top: Hinged at back or lift off for easy cleaning and access to burners, valves, and pilots.
    a. Hinge Top: May have supporting rod to hold top in raised position or be removable. Design supporting rod, when in raised position, to prevent accidental closing of range top. Counterbalanced top is also acceptable.

38. Cooking Top Burners/Low Setting: Equip each range with burners with low settings not in excess of 400 W (1400 BTU/H).
39. Leg levelers: Equip each range with at least two leg levelers.
40. Manifold Shield: Provide recessed or slanted manifold shield to minimize burning of burner knobs from heat from open oven doors.
41. Oven Door: Provide 610 mm (24 inch), 760 mm (30 inch) and 910 mm (36 inch) ranges with removable oven door.

EXECUTION

Examination

42. Site Verification of Conditions:
    a. Utilities: Verify that required utilities are available, in proper locations, and ready for use.

Preparation

43. Existing Ranges: Remove existing ranges and debris from site.

Installation

44. General: Install gas ranges in accordance with manufacturer's recommendations.
    a. Make connection to gas line in accordance with applicable codes.
    b. Make adjustments to feet of ranges for a level installation.

Cleaning

45. Cleaning: Comply with requirements of Division 1.

Schedules

46. Provide gas ranges as selected in following schedule:

_____ Remove existing ranges.

_____ Supply and Deliver Only to _____.

_____ Unloading and handling included.

_____ Supply and Install.

SELECTION	NUMBER OF	SIZE	COLOR	TYPE BURNERS
____	4 Burner	510 mm (20 Inch)	_____	Type A Economy or Builders Model.
____	4 Burner	610 mm (24 Inch)	_____	Type A Economy or Builders Model.
____	4 Burner	760 mm (30 Inch)	_____	Type A Economy or Builders Model.
____	4 Burner	910 mm (36 Inch)	_____	Type A Economy or Builders Model.
____	4 Burner	510 mm (20 Inch)	_____	Type C Quality Model.
____	4 Burner	610 mm (24 Inch)	_____	Type C Quality Model.
____	4 Burner	760 mm (30 Inch)	_____	Type C Quality Model.
____	4 Burner	910 mm (36 Inch)	_____	Type C Quality Model.

END OF SECTION11910b

SECTION 11910c - ELECTRIC RANGES

GENERAL

Summary

1. Section Includes:
   a. Remove existing ranges.
   b. Electric ranges, supply and deliver only or supply and install as scheduled.
2. Related Requirements: Comply with requirements of following sections:
   a. Contractor Use of Premises and Work Sequence: Section “Summary of Work.”
   b. Section “Alteration Project Procedures.”
3. Related Sections:
   a. Kitchen Renovation Requirements: Section “Summary of Work.”
   b. Reference Standards: Section “References.”
   c. Gas Ranges: Section “Gas Ranges.”
   d. Electrical Renovation: Section “Electrical Renovation.”

References

4. Reference Standards: See Section “References.” Comply with following:
   a. Association of Home Appliance Manufacturers (AHAM) ER-1 - American National Standard Household Electric Ranges, 1992.
   b. Federal Specification (FS): WR-101F dated March 13, 1970, and Interim Amendment 2 dated December 31, 1970.
   c. Underwriter's Laboratories (UL): ANSI/UL 858 - Household Electric Ranges, 1986.
   d. Certification:
      1) ANSI Z34.1 - Certification, Third-Party Certification Program, 1987.
      2) ANSI Z34.2 - Certification, Self-Certification by Producer or Supplier, 1987.

Definitions

5. Standard Ranges: Four Surface Cooking Units: Three - 150 mm (6 inch) and one - 200 mm (8 inch) with oven and broiler below.
   a. Type, Style, and Sizes as defined in FS W-R-101F:
      1) Type I: Freestanding range.
      2) Type II: Build-in (slide-in) range.
      3) Style 1: Single oven.
      4) Style 2: Double oven 1 020 mm (40 inches) wide.
      5) Size 1: 1 020 mm (40 inches) wide.
      6) Size 2: 910 mm (36 inches) wide.
      7) Size 3: 760 mm (30 inches) wide.
      8) Size 4: 610 mm (24 inches) wide.
      9) Size 5: 510 mm (20 inches) wide.
6. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by PHA/IHA.

Submittals

7. Product Data: Submit to the Owner.
8. Samples:
   a. Production Sample: When requested, provide sample electric range to the Owner for examination as to compliance with specifications.
   b. Color Samples: Submit samples of manufacturer s standard colors to the Owner for selection.
9. Quality Assurance/Control Submittals: Submit following to the Owner:
   a. Certificates: Manufacturer's written certification that electric ranges meet or exceed specified requirements including UL requirements and requirements of FS WR-101F.

b. Manufacturer's installation instructions.

10. Closeout Submittals: Submit following to the Owner:
    a. Operation and Maintenance Instructions: Provide use and care information with each range. Include parts manual with diagrams and part numbers.
    b. Special warranty.

Quality Assurance

11. Qualifications: Manufacturer: Stock and sell parts for ranges supplied for five years from time of delivery.
12. Regulatory Requirements: Comply with following:
    a. Accessibility:
        1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
            a) Uniform Federal Accessibility Standards (UFAS).
        2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
        3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
        4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).
13. Appliances shall meet or exceed requirements established by the Energy Star program and bear the Energy Star logo. Visit www.energystar.gov for a listing of products that qualify. Energy Star® is a voluntary partnership that includes the U.S. Department of Energy, the U.S. Environmental Protection Agency, product manufacturers, local utilities, and retailers, helps promote efficient products by labeling them with the Energy Star logo and educating consumers about the benefits of energy efficiency.

Delivery, Storage, And Handling

14. Packing, Shipping, Handling, and Unloading: In accordance with standard commercial practices.
15. Acceptance at Site: Inspect electric ranges upon delivery. Replace damaged or defective appliances before installation.

Scheduling

16. Scheduling and Completion: Comply with requirements of Division 1.

Warranty

17. Special Warranties: Provide following written special warranties:
    a. Entire electric range for one year.
18. Special Warranties: Include labor, material and equipment to provide replacements and make repairs to electric ranges at no additional cost to PHA/IHA.
    a. Defective Units and/or Parts: Become property of Contractor.
    b. Submit name and address of local agent who will furnish service and replacement parts in connection with warranties to PHA/IHA.
        1) Charges by local service agent to PHA/IHA for services covered under special warranties not allowed.

PRODUCTS

Electric Ranges

19. Ranges: AHAM ER-1, ANSI/UL 858, and FS WR-101F, current standard models of manufacturer except for additional requirements specified.
    a. Ranges: Floor mounted, free standing flush-to-wall, domestic electric ranges with open cooking top, oven and broiler below.
    b. Ranges of Same Classification: Identical, including parts and assemblies.
    c. Ranges: UL listed and bear UL label.

20. Operating Service: 115/230 volts or 120/208 volts, 3-wire, single-phase, 60-HZ.
    a. Type of Service: As scheduled.
21. Ranges:
    a. Each Range: Equipped with at least two leg levelers.
    b. Oven Door: Equip 610 mm (24 inch), 760 mm (30 inch), and 910 mm (36 inch) ranges with removable oven door.
    c. Ranges without Storage Drawer: May be equipped with only one oven rack.

Ranges For Elderly Housing

22. Ranges for Elderly Housing: Same as above, Type I or II, Style 1, Sizes 4 and 5, standard electric ranges but, as minimum, include following additional items:
    a. Location of Controls for Ranges and Cook-Tops: Not require reaching across burners.
    b. Burner Indicator Lights: Provide light for each top burner and oven unit that will clearly indicate when burner is on.
        1) Indicator Light: Integral part of, or adjacent to, each control switch or adjacent to each top burner unit.
    c. Oven Interior Light: Provide light in each oven that will clearly illuminate interior when oven door is open.

EXECUTION

Examination

23. Site Verification of Conditions:
    a. Utilities: Verify that required utilities are available, in proper locations, and ready for use.

Preparation

24. Existing Ranges: Remove existing ranges and debris from site.

Installation

25. General: Install electric ranges in accordance with manufacturer's recommendations.
    a. Make adjustments to feet of ranges for a level installation.
    b. Electrical Renovation: See Section 16095.

Cleaning

26. Cleaning: Comply with requirements of Division 1.

Schedules

27. Provide electric ranges as selected in following schedule:

_____Remove existing ranges.

_____Supply and Deliver Only to_____.

_____Unloading and handling included.

_____Supply and Install.

SELECTION	NUMBER BURNERS	ELECTRIC SERVICE	COLOR	TYPE AND SIZE
_____	4 Burner	_____	_____	Type I, Style I, Size 1, 1 020 mm (40 inches) wide).
_____	4 Burner	_____	_____	Type I, Style I, Size 2, 910 mm (36 inches) wide.
_____	4 Burner	_____	_____	Type I, Style I, Size 3, 760 mm (30 inches) wide.
_____	4 Burner	_____	_____	Type I, Style I, Size 4, 610 mm (24 inches) wide.
_____	4 Burner	_____	_____	Type I, Style I, Size 5, 510 mm (20 inches) wide.
_____	4 Burner	_____	_____	Type I or II, Style I, Size 5, 510 mm (20 inches) wide with specified elderly housing requirements.

_____	4 Burner	_____	_____	Type I or II, Style I, Size 4, 610 mm (24 inches) wide with specified elderly housing requirements.

END OF SECTION11910c

SECTION 11910d - RANGE HOODS

GENERAL

Summary

1. Section Includes:
   a. Remove existing range hoods.
   b. Range hoods, supply and deliver only or supply and install as scheduled.
2. Related Requirements: Comply with requirements of following sections:
   a. Contractor Use of Premises and Work Sequence: Section “Summary of Work.”
   b. Section “Alteration Project Procedures.”
3. Related Sections:
   a. Kitchen Renovation Requirements: Section “Summary of Work.”
   b. Reference Standards: Section “References.”
   c. Gas Ranges: Section “Gas Ranges.”
   d. Electric Ranges: Section “Electric Ranges.”
   e. Residential Cabinets: Section “Residential Cabinets.”
   f. Electrical Hook-up: Section “ Electrical Renovation.”

References

4. Reference Standards: See Section “References.” Comply with following:
   a. National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).
   b. Certification:
      1) ANSI Z34.1 - Certification, Third-Party Certification Program, 1987.
      2) ANSI Z34.2 - Certification, Self-Certification by Producer or Supplier, 1987.

Definitions

5. Supply and Delivery Only: Include supply and delivery to site(s) FOB destination freight prepaid. Unless otherwise specified or scheduled, unloading and handling at site is by PHA/IHA.

Submittals

6. Product Data: Submit to the Owner.
7. Samples: Submit to the Owner.
   Production Sample: When requested, provide sample range hood to the Owner for examination as to compliance with specifications.
   a. Color Samples: Samples of manufacturer s standard colors for selection.
8. Quality Assurance/Control Submittals: Submit following to the Owner:
   a. Certificates: Manufacturer's written certification that range hoods meet or exceed specified requirements including UL requirements.
   b. Manufacturer's installation instructions.
   c. Appliances shall meet or exceed requirements established by the Energy Star program and bear the Energy Star logo. Visit www.energystar.gov for a listing of products that qualify. Energy Star® is a voluntary partnership that includes the U.S. Department of Energy, the U.S. Environmental Protection Agency, product manufacturers, local utilities, and retailers, helps promote efficient products by labeling them with the Energy Star logo and educating consumers about the benefits of energy efficiency.
   d. Closeout Submittals: Submit following to the Owner:
      1) Operation and Maintenance Instructions: Provide use and care information with each range hood. Include parts manual with diagrams and part numbers.
   e. Special warranty.

Quality Assurance

9. Qualifications: Manufacturer: Stock and sell parts for range hoods supplied for five years from time of delivery.

10. Regulatory Requirements: Comply with following:
    a. Accessibility:
        1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
            a) Uniform Federal Accessibility Standards (UFAS).
        2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
        3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
        4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).

Delivery, Storage, And Handling

11. Packing, Shipping, Handling, and Unloading: In accordance with standard commercial practices.
12. Acceptance at Site: Inspect range hoods upon delivery. Replace damaged or defective appliances before installation.

Scheduling

13. Scheduling and Completion: Comply with requirements of Division 1.

Warranty

14. Special Warranties: Provide following written special warranties:
    a. Entire range hood for one year.
15. Special Warranties: Include labor, material and equipment to provide replacements and make repairs to range hoods at no additional cost to PHA/IHA.

PRODUCTS

Range Hoods

16. Range Hoods: Ductless type with fan.
    a. Size: 610 mm (24 inches) or 760 mm (30 inches) wide as scheduled, by 150 mm (6 inches) high by 445 mm (17.5 inches) deep.
    b. Hoods: UL listed and bear UL label.
    c. Fan: 120 V, 60 HZ, two speed, 2.0 A fan.
    d. Light: Enclosed 75 watt.
    e. Filter: Washable filter.
    f. Color: As selected from manufacturer s standard colors.
17. Range Hood Shell: Same as range hoods above without fan and without light.
    a. Size: 610 mm (24 inches) or 760 mm (30 inches) wide as scheduled, by 150 mm (6 inches) high by 445 mm (17.5 inches) deep.
    b. Color: As selected from manufacturer standard colors.

EXECUTION

Examination

18. Site Verification of Conditions:
    a. Utilities: Verify that required utilities are available, in proper locations, and ready for use.
    b. Cabinets: Verify that adjacent residential cabinets and range hood are coordinated.

Preparation

19. Existing Range Hoods: Remove existing range hoods and debris from site.

Installation

20. General: Install range hoods in accordance with manufacturer's recommendations.
    a. Electrical Hook-up: See electrical specifications.

Cleaning

21. Cleaning: Comply with requirements of Division 1.

Schedules

22. Provide range hoods as selected in following schedule:

_____Remove existing range hoods.

_____Supply and Deliver Only to _____.

_____Unloading and handling included.

_____Supply and Install.

_____Range Hood (with fan, filter, and light).

_____760 mm (30 inches) wide.

_____610 mm (24 inches) wide.

_____Range Hood Shell.

_____760 mm (30 inches) wide.

_____610 mm (24 inches) wide.

END OF SECTION11910d

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Task	Specification	Specification Description
11920	11910	Residential Appliances
11940	01352	No Specification Required

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SECTION 12201 - DRAPERIES AND TRACKS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for draperies and tracks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes draperies and drapery tracks.

C. Submittals
1. Product Data: For the following:
   a. Tracks: Include maximum weights of draperies that can be supported.
      1) Motorized Tracks: Indicate motor weights, motor-mounting requirements, and electrical requirements.
   b. Fabrics and textile treatments.
2. Shop Drawings: For tracks. Show installation and anchorage details, locations of components and controls, and field measurements.
   a. Draperies: Show sizes, locations, and details of installation.
3. Coordination Drawings: For track installation; reflected ceiling plans drawn to scale and coordinating track installation with openings and ceiling-mounted items.
4. Samples: For each drapery and for each fabric color and texture required.
5. Product Schedule: Use same designations indicated on Drawings.
6. Product Certificates: For each fabric treated with flame retardant, signed by fabric supplier.
7. Maintenance data.

D. Quality Assurance
1. Installer Qualifications: For draperies and tracks, fabricator of draperies.
2. Source Limitations: For draperies, obtain each color and pattern of fabric and trim from one dye lot.
3. Fire-Test-Response Characteristics: For fabrics treated with fire retardants, provide products that pass NFPA 701 as determined by testing of fabrics that were treated using treatment-application method intended for use for this Project by a testing and inspecting agency acceptable to authorities having jurisdiction.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Corded Window Covering Product Standard: Provide drapery tracks operated by pull cords complying with ANSI A100.1.

1.2 PRODUCTS

A. Drapery Tracks
1. Manually Operated Track:
   a. Construction: Extruded aluminum, slotted for mounting at interval of not more than 24 inches (610 mm) o.c., and bendable to radii indicated.
      1) Lengths and Configurations: As directed.
      2) Support Capability: Weight of drapery indicated **OR** 30 lb (14 kg) **OR** 45 lb (20 kg) **OR** 60 lb (27 kg) **OR** 80 lb (36 kg) **OR** 140 lb (64 kg) **OR** 210 lb (95 kg), **as directed,** mounted on track length indicated.

3) Finish: Manufacturer's standard **OR** White baked enamel **OR** Clear anodic coating, **as directed**.

b. Mounting Brackets: Aluminum, of type suitable for fastening track to surface indicated and designed to support weight of track assembly and drapery plus force applied to operate track.

1) Mounting Surface: As indicated on Drawings **OR** Wall **OR** Ceiling **OR** Drapery pocket, **as directed**.

c. Installation Fasteners: Sized to support track assembly and drapery, and fabricated from metal compatible with track, brackets, and supporting construction. Provide two fasteners to fasten each bracket to supporting construction.

d. Operation: Baton **OR** Cord **OR** Cord tension pulley, **as directed**.

1) Pulley Mounting Location: Wall **OR** Baseboard **OR** Floor, **as directed**.

2) Draw: One way, stack as indicated on Drawings **OR** One way, stack left **OR** One way, stack right **OR** Two way, center opening, **as directed**.

3) Operating Hardware Location: On stack side **OR** Left **OR** Right **OR** As indicated on Drawings, **as directed**.

e. Carriers: Rollers **OR** Rollers with hooks **OR** Rollers with snaps **OR** Coordinate with drapery headings indicated, **as directed**.

1) Master Carriers: Butt **OR** Overlap, **as directed**.

f. Accessories: <Insert accessories.>

2. Motorized Track:

a. Construction: Extruded aluminum, slotted for mounting at interval of not more than 24 inches (610 mm) o.c., and bendable to radii indicated.

1) Lengths and Configurations: As directed.

2) Support Capability: Weight of drapery indicated **OR** 30 lb (14 kg) **OR** 45 lb (20 kg) **OR** 60 lb (27 kg) **OR** 80 lb (36 kg) **OR** 140 lb (64 kg) **OR** 210 lb (95 kg), **as directed**, mounted on track length indicated.

3) Finish: Manufacturer's standard **OR** White baked enamel **OR** Clear anodic coating, **as directed**.

b. Mounting Brackets: Suitable for fastening track to surface indicated and designed to support weight of track assembly and drapery plus force applied to operate track.

1) Mounting Surface: As indicated on Drawings **OR** Wall **OR** Ceiling **OR** Drapery pocket, **as directed**.

c. Installation Fasteners: Sized to support track assembly and drapery, and fabricated from metal compatible with track, brackets, and supporting construction. Provide two fasteners to fasten each bracket to supporting construction.

d. Motor Operation: Low-voltage motor with built-in low-voltage interface for direct access to control systems, with thermal-overload switch; sized for weight of drapery and track length indicated; and equipped with stops to prevent overdrawing.

1) Control: Wall switch **OR** Remote, infrared **OR** Remote, radio controlled **OR** Digital timer, **as directed**.

2) Draw: One way, stack as indicated on Drawings **OR** One way, stack left **OR** One way, stack right **OR** Two way, center opening, **as directed**.

3) Electrical Requirements: 115 V/60 Hz/120 W/1.10 A **OR** 115 V/60 Hz/140 W/1.20 A **OR** 110 V/60 Hz/150 W/1.0 A **OR** 110 V/60 Hz/550 W/5.0 A, **as directed**.

4) Travel Speed: 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** 12 inches (305 mm), **as directed**, per second.

e. Carriers: Rollers **OR** Rollers with hooks **OR** Rollers with snaps **OR** Coordinate with drapery headings indicated, **as directed**.

1) Master Carriers: Butt **OR** Overlap, **as directed**.

f. Accessories: <**Insert accessories**.>

B. Draperies

1. Drapery:

a. Heading:

1) Pinch (French) Pleats: 100 **OR** 150 **OR** 200, **as directed**, percent fullness.
2) Stack Pleats: 60 **OR** 80 **OR** 100 **OR** 120, **as directed**, percent fullness.
3) Roll Pleats: 60 **OR** 80 **OR** 100 **OR** 120, **as directed**, percent fullness.
4) Accordion Pleats: 40 **OR** 80 **OR** 100 **OR** 120, **as directed**, percent fullness.
5) Pleat Spacing: <**Insert dimension**.>
6) Heading Accessories:
   a) Nonwoven buckram.
   b) Woven snap tape, 7/8 inch (22 mm) wide, with nickel-plated snaps at 4 inches (102 mm) o.c.
   c) Hooks.

b. Drapery Fabric:
1) Manufacturer, Designation, Pattern, Color, and Fiber Content: **As directed**.
2) Orientation: Run right (up the bolt).
3) Width and Pattern Repeat Distance: **As directed**.
4) Textile Treatments: Stain repellent **OR** Flame retardant, polymer type **OR** Stain repellent; and flame retardant, polymer type, **as directed**.

c. Lining Fabric:
1) Lining Type: Blackout; light tight **OR** Water resistant, **as directed**.
2) Manufacturer, Manufacturer's Designation, Color, Fiber Content, and Width: As directed.
3) Textile Treatments: Stain repellent **OR** Flame retardant, polymer type **OR** Stain repellent; and flame retardant, polymer type, **as directed**.

d. Interlining: Acoustical.
1) Manufacturer: **As directed**.

e. Textile Trim and Tiebacks: **As directed.**

f. Hem Weights: 1-inch- (25-mm-) square lead weights **OR** Tape type (string weights), **as directed**.

C. Drapery Fabrication
1. Fabricate draperies in heading styles and fullnesses indicated. Fabricate headings to stand erect. If less than a full width of fabric is required to produce panel of specified fullness, use equal widths of not less than one-half width of fabric located at ends of panel.
   a. One-Way-Stacking Draperies: Add 5 inches (127 mm) to overall width for returns.
   b. Center-Opening Draperies: Add 10 inches (254 mm) to overall width for overlap.
2. Seams: Sew vertical seams with twin-needle sewing machine with selvage trimmed and overlocked. Join widths so that patterns match and vertical seams lay flat and straight without puckering. Horizontal seams are not acceptable.
3. Side Hems: Double-turned, 1-1/2-inch- (38-mm-) wide hems consisting of three layers of fabric, and blindstitched so that stitches are not visible on face of drapery.
4. Bottom Hems: Double-turned, 4-inch- (102-mm-) wide hems consisting of three layers of fabric, and weighted and blindstitched so that weights and stitches are not visible on face of drapery.
   a. Sew in square lead weights at each seam and at panel corners.
5. Interlinings: Extend from top of drapery to within 1/2 inch (13 mm) of lining's bottom hem and to leading edge of side hems to produce full-shadowed appearance.
6. Linings: Equal to widths of drapery fabric and joined to drapery fabric at top by inside invisible seam, and hand stitched at side hems and shadowed with 1-1/2-inch (38-mm) return of face fabric.
   a. Bottom Hem: Hem separately from **OR** Blind stitch to, **as directed,** drapery fabric.

1.3 EXECUTION

A. Drapery Track Installation
1. Install track systems according to manufacturer's written instructions, level and plumb, and at height and location in relation to adjoining openings as indicated on Drawings.

2. Isolate metal parts of tracks and brackets from concrete, masonry, and mortar to prevent galvanic action. Use tape or another method recommended in writing by track manufacturer.

B. Drapery Installation
1. Where draperies abut overhead construction, hang draperies so that clearance between headings and overhead construction is 1/4 inch (6.4 mm).
2. Where draperies extend to floor, install so that bottom hems clear finished floor by not more than 1 inch (25 mm) and not less than 1/2 inch (13 mm).
3. Where draperies extend to windowsill, install so that bottom hems hang above sill line and clear sill line by not more than 1/2 inch (13 mm).

C. Adjusting
1. After hanging draperies, test and adjust each track to produce unencumbered, smooth operation.
2. Steam and dress down draperies as required to produce crease- and wrinkle-free installation.
3. Remove and replace draperies that are stained or soiled.

END OF SECTION 12201

SECTION 12210 - HORIZONTAL LOUVER BLINDS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for horizontal louver blinds. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Horizontal louver blinds with aluminum, wood and polymer slats.
b. Motorized blind operators.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Show fabrication and installation details for horizontal louver blinds and motorized blind operators.
a. Wiring Diagrams: Power, system, and control wiring.
3. Samples: For each exposed finish.
4. Product certificates **OR** test reports, **as directed**.
5. Maintenance data.

D. Quality Assurance
1. Fire-Test-Response Characteristics: Provide horizontal louver blinds with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
a. Flame-Resistance Ratings: Passes NFPA 701.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Product Standard: Provide horizontal louver blinds complying with WCSC A 100.1.

E. Delivery, Storage, And Handling
1. Deliver horizontal louver blinds in factory packages, marked with manufacturer and product name, fire-test-response characteristics, lead-free designation, and location of installation using same designations indicated on Drawings and in a window treatment schedule.

1.2 PRODUCTS

A. Horizontal Louver Blinds, Aluminum Slats
1. Slats: Aluminum; alloy and temper recommended by producer for type of use and finish indicated; with crowned profile and radiused corners.
a. Width: 2 inches (51 mm) **OR** 1 inch (25 mm) **OR** 1/2 to 5/8 inch (13 to 16 mm), **as directed**.
b. Finish: One color **OR** One color each side **OR** As indicated, **as directed**.
1) Ionized Coating: Antistatic, dust-repellent, baked polyester finish.
2) Reflective Coating: Manufacturer's special coating enhancing the reflection of solar energy on the outside-facing slat surface.
c. Perforated Slats: Openness factor of 6 to 7 percent.

2. Headrail: Formed steel or extruded aluminum; long edges returned or rolled; fully enclosing operating mechanisms on three sides and end plugs.
3. Bottom Rail: Formed-steel or extruded-aluminum tube, with plastic or metal capped ends.
4. Maximum Light-Blocking Blinds: Designed for eliminating all visible light gaps if slats are tilted closed and with minimal-sized rout holes for ladders hidden and placed near back edge for maximum slat overlap; with headrail and bottom rail extended and formed for light-tight joints between rail and adjacent slats or construction.
   a. Finish: Match color, texture, pattern, and gloss of slats **OR** Color, texture, pattern, and gloss differing from slats as indicated by manufacturer's designations **OR** Color, texture, pattern, and gloss differing from slats, matching samples **OR** Color texture, pattern, and gloss differing from slats as selected from manufacturer's full range, **as directed**.
5. Ladders: Evenly spaced to prevent long-term slat sag.
   a. For Blinds with Nominal Slat Width 1 Inch (25 mm) or Less: Braided string.
   b. For Blinds with Nominal Slat Width 1 Inch (25 mm) **OR** 2 Inches (51 mm)\, **as directed**, or More: Braided string **OR** Manufacturer's standard-width reinforced vinyl tapes **OR** Manufacturer's standard-width cloth tapes, **as directed**.
      1) Tape Color, Texture, and Pattern: Color, texture, and pattern as indicated by manufacturer's designations **OR** Color, texture, and pattern matching samples **OR** Color, texture, and pattern as selected from manufacturer's full range, **as directed**.
6. Lift-and-Tilt Control: Motorized operator.
7. Lift Cords: Manufacturer's standard.
8. Tilt Control: Enclosed worm-gear mechanism, slip clutch or detachable wand preventing overrotation, and linkage rod.
9. Lift Operation: Manual.
10. Valance: Two slats **OR** PVC strip **OR** Manufacturer's standard, **as directed**.
11. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
12. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard.
13. Side Channels and Perimeter Light Gap Seals: Manufacturer's standard.
14. Colors, Textures, Patterns, and Gloss: As selected from manufacturer's full range.

B. Horizontal Louver Blinds, Wood Slats
1. Slats: Hardwood, North American **OR** basswood **OR** poplar **OR** ramin, **as directed,** species, flame-retardant treated; with flat profile and radiused corners and beaded edges **OR** and double beaded edges, **as directed**.
   a. Width: 1 inch (25 mm) **OR** 1-3/8 inch (35 mm) **OR** 2 inches (51 mm) **OR** 2-3/8-inch (60-mm), **as directed**.
   b. Finish: Manufacturer's standard colors as indicated, for striped blind with pattern as indicated on Drawings.
2. Headrail: Formed steel or extruded aluminum; long edges returned or rolled; fully enclosing operating mechanisms on three sides and ends.
3. Bottom Rail: Hardwood matching slats.
   a. Finish Color Characteristics: Match color, texture, pattern, and gloss of slats **OR** Match color, texture, pattern, and gloss of valance **OR** Color, texture, pattern, and gloss differing from slats as indicated by manufacturer's designations **OR** Color, texture, pattern, and gloss differing from slats, matching samples **OR** Color texture, pattern, and gloss differing from slats as selected from manufacturer's full range, **as directed**.
4. Maximum Light-Blocking Blinds: Designed for eliminating all visible light gaps if slats are tilted closed and with minimal-sized rout holes for ladders hidden and placed near back edge for maximum slat overlap; with headrail and bottom rail extended and formed for light-tight joints between rail and adjacent slats or construction.
5. Ladders: Braided string **OR** Manufacturer's standard-width cloth tapes, **as directed**. Evenly spaced to prevent long-term louver sag.

a. Tape Color, Texture, and Pattern: Color, texture, and pattern as indicated by manufacturer's designations **OR** Color, texture, and pattern matching samples **OR** Color, texture, and pattern as selected from manufacturer's full range, **as directed**.

6. Tilt Control: Enclosed worm gear mechanism, slip clutch or detachable wand preventing overrotation, and linkage rod.
7. Lift Operation: Manual.
8. Lift Operation: Motorized operator.
9. Valance: Manufacturer's standard.
10. Cornice: as directed by the Owner.
11. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
12. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard, as indicated.
13. Colors, Textures, Patterns, and Gloss: As selected from manufacturer's full range.

C. Horizontal Louver Blinds, Polymer Slats

1. Slats: Lead-free, UV-stabilized, integrally colored, opaque, permanently flexible, extruded PVC **OR** polymer/wood alloy, **as directed,** that will not crack or yellow; antistatic, dust-repellent treated; with crowned **OR** manufacturer's standard, **as directed,** profile.
   a. Width: 2 inches (51 mm) **OR** 2-1/2 inches (64 mm), **as directed**.
      1) Spacing: Manufacturer's standard.
   b. Finish: Wood-tone **OR** Painted, **as directed,** color as indicated.
   c. Finish: Two colors **OR** textures **OR** patterns, **as directed,** as indicated, one per side of slat.
2. Headrail: Formed steel or extruded aluminum; long edges returned or rolled; fully enclosing operating mechanisms on three sides and ends.
3. Bottom Rail: Manufacturers standard **OR** Formed-steel or extruded-aluminum tube, with plastic or metal capped ends **OR** Hardwood matching slats and trapezoid-shaped bottom angled for minimizing light gaps, **as directed**.
4. Ladders: Braided string **OR** Manufacturer's standard-width cloth tapes, **as directed**. Evenly spaced to prevent long-term slat sag.
   a. Tape Color, Texture, and Pattern: Color, texture, and pattern as selected from manufacturer's full range.
5. Tilt Control: Enclosed worm-gear mechanism and linkage rod.
6. Lift Operation: Manual.
7. Lift Operation: Motorized operator.
8. Valance: Manufacturer's standard.
9. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
10. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard, as indicated.
11. Colors, Textures, Patterns, and Gloss: As selected from manufacturer's full range.

D. Horizontal Louver Blind Fabrication

1. Concealed Components: Noncorrodible or corrosion-resistant-coated materials.
   a. Lift-and-Tilt Mechanisms: With permanently lubricated moving parts.
2. Unit Sizes: Obtain units fabricated in sizes to fill window and other openings as follows:
   a. Blind Units Installed between (inside) Jambs: Width equal to 1/4 inch (6 mm) per side or 1/2 inch (13 mm) total, plus or minus 1/8 inch (3.1 mm), less than jamb-to-jamb dimension of opening in which each blind is installed. Length equal to 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm), less than head-to-sill dimension of opening in which each blind is installed.
   b. Blind Units Installed outside Jambs: Width and length as indicated, with terminations between blinds of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.
3. Installation Brackets: Designed for easy removal and reinstallation of blind, for supporting headrail, valance, and operating hardware, and for hardware position and blind mounting method indicated.

4. Installation Fasteners: No fewer than two fasteners per bracket, fabricated from metal noncorrosive to blind hardware and adjoining construction; type designed for securing to supporting substrate; and supporting blinds and accessories under conditions of normal use.
5. Color-Coated Finish:
   a. Metal: For components exposed to view, apply manufacturer's standard baked finish.
   b. Wood: Apply manufacturer's standard opaque **OR** transparent, **as directed,** factory-applied finish.
6. Component Color: Provide rails, cords, ladders, and exposed-to-view metal, wood, and plastic matching or coordinating with slat color, unless otherwise indicated.

E. Motorized Horizontal Louver Blind Operators
1. General: Provide factory-assembled blind operation systems designed for blind type, size, weight, construction, use, and operation frequency indicated, with lift **OR** tilt **OR** lift-and-tilt, **as directed,** functions. Provide operation systems of size and capacity and with features, characteristics, and accessories suitable for Project conditions and recommended by blind manufacturer, complete with electric motors and factory-prewired motor controls, remote-control stations, remote-control devices, power disconnect switches, enclosures protecting controls and all operating parts, headrail, and accessories required for reliable operation without malfunction. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with building electrical system.
2. Comply with NFPA 70.
3. Control Equipment: Comply with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6 with NFPA 70, Class 2 control circuit, maximum 24-V ac or dc.
4. Electric Motors: UL-approved or -recognized, totally enclosed, insulated motor, complying with NEMA MG 1, with thermal-overload protection and internal limit switches; sized by blind manufacturer to start and operate size and weight of blind considering service factor or Project's service conditions without exceeding nameplate ratings.
   a. Service Factor: According to NEMA MG 1, unless otherwise indicated.
   b. Motor Characteristics: Single phase, 24 **OR** 110 **OR** 220, **as directed,** V, 60 Hz.
   c. Motor Mounting: Within manufacturer's standard headrail enclosure.
5. Remote Controls: Electric controls with NEMA ICS 6, Type 1 enclosure for surface **OR** recessed or flush **OR** within headrail, **as directed,** mounting. Provide the following devices for remote-control activation of blinds:
   a. Control Stations: Keyed, maintained **OR** momentary, **as directed,**-contact, three-position, switch-operated control station with open, close, and off functions. Provide two keys per station.
   b. Control Stations: Maintained **OR** Momentary, **as directed,**-contact, three-position, toggle **OR** rocker, **as directed,**-style, wall-switch-operated control station with open, close, and center off functions.
      1) Color: Ivory **OR** White **OR** As indicated, **as directed**.
6. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop blind at fully raised and fully lowered positions.
7. Operating Features: as directed by the Owner.
8. Accessories:
   a. Solar Power Unit: For use with control system indicated.

1.3 EXECUTION

A. Installation
1. Install horizontal louver blinds level and plumb and aligned with adjacent units according to manufacturer's written instructions, and located so exterior slat edges in any position are not closer than 1 inch (25 mm) **OR** 2 inches (51 mm), **as directed,** to interior face of glass. Install intermediate support as required to prevent deflection in headrail. Allow clearances between adjacent blinds and for operating glazed opening's operation hardware if any.

2. Flush Mounted: Install horizontal louver blinds with slat edges flush with finish face of opening if slats are tilted open.
3. Jamb Mounted: Install headrail flush with face of opening jamb and head.
4. Head Mounted: Install headrail on face of opening head.
5. Recessed: Install headrail concealed within blind pocket.
6. Connections: Connect motorized operators to building electrical system.
7. Adjust horizontal louver blinds to operate smoothly, easily, safely, and free of binding or malfunction throughout entire operational range.
8. Clean horizontal louver blind surfaces after installation, according to manufacturer's written instructions.

END OF SECTION 12210

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SECTION 12210a - VERTICAL LOUVER BLINDS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for vertical louver blinds. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Vertical louver blinds, aluminum vanes, PVC vanes, PVC vanes with fabric vane insert and fabric vanes.
b. Motorized blind operators.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Show fabrication and installation details for vertical louver blinds and motorized operators.
a. Wiring Diagrams: Power, system, and control wiring.
3. Samples: For each exposed finish.
4. Product certificates **OR** test reports, **as directed**.
5. Maintenance data.

D. Quality Assurance
1. Fire-Test-Response Characteristics: Provide vertical louver blinds with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.
a. Flame-Resistance Ratings: Passes NFPA 701.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Product Standard: Provide vertical louver blinds complying with WCSC A 100.1.

E. Delivery, Storage, And Handling
1. Deliver vertical louver blinds in factory packages, marked with manufacturer and product name, fire-test-response characteristics, lead-free designation, and location of installation using same designations indicated on Drawings and in a window treatment schedule.

1.2 PRODUCTS

A. Vertical Louver Blinds, Aluminum Vanes
1. Rail System: Headrail **OR** Dual system with headrail and bottom rail, **as directed**.
a. Rails: Extruded aluminum **OR** Formed steel **OR** Manufacturer's standard, **as directed**; long edges returned or rolled; channel-shaped, enclosing operating mechanisms.
1) Color: Custom color **OR** As selected from manufacturer's standard color range, **as directed**.
2) Anodized aluminum, clear **OR** color, **as directed,** anodized.

2. Vanes: Aluminum, alloy, and temper recommended by producer for type of use and finish indicated; with crowned profile and not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed.
   a. Nominal Vane Width: 3-1/2 inches (89 mm) wide.
   b. Vane Finish: One color as indicated, **OR** Two colors as indicated, one per side of slat, **as directed**.
3. Vane Directional Control: Manual **OR** Motorized operator, **as directed**.
4. Traversing Control: Manual **OR** Motorized operator, **as directed**.
5. Draw and Stack Position: One way, controls and stack left **OR** One way, controls and stack right **OR** One way, controls left and stack opposite **OR** One way, controls right and stack opposite **OR** Center split, controls left **OR** Center split, controls right **OR** Center stack, controls left **OR** Center stack, controls right **OR** Off center, controls left **OR** Off center, controls right **OR** As indicated on Drawings **OR** As indicated in a window treatment schedule, **as directed**.
6. Cord-Tensioner Mounting: Wall **OR** Floor **OR** Sill **OR** Baseboard **OR** As indicated, **as directed**.
7. Valance: One **OR** Two-tiered, **as directed,** vane insert; with dust cover.
   a. Finish Color Characteristics: Match color, texture, pattern, and gloss of vanes **OR** Color, texture, pattern, and gloss differing from vanes as indicated by manufacturer's designations **OR** Color, texture, pattern, and gloss differing from vanes matching samples **OR** Color texture, pattern, and gloss differing from vanes as selected from manufacturer's full range, **as directed**.
8. Louver Bottom: Connecting or spacing chains.
9. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
10. Stack Release: Permitting stacked vanes to be moved away from stacking position for total access to glazed opening.
11. Colors, Textures, Patterns, and Gloss: As selected from manufacturer's full range.

B. Vertical Louver Blinds, PVC Vanes
1. Rail System: Headrail **OR** Dual system with headrail and bottom rail, **as directed**.
   a. Rails: Extruded aluminum **OR** Formed steel **OR** Manufacturer's standard, **as directed**; long edges returned or rolled; channel-shaped, enclosing operating mechanisms.
      1) Color: Custom color **OR** As selected from manufacturer's standard color range, **as directed**.
      2) Anodized aluminum, clear **OR** color, **as directed,** anodized.
2. Vanes: Lead-free, UV-stabilized, integrally colored, opaque, permanently flexible, extruded PVC that will not crack or yellow; with flat **OR** crowned **OR** ribbed, **as directed,** profile and not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed.
   a. Nominal Vane Width: 2 inches (51 mm) **OR** 3-1/2 inches (89 mm) **OR** 4 inches (100 mm) **OR** 5 inches (125 mm), **as directed**.
   b. Perforated Vanes: Openness factor of 3 **OR** 6 **OR** 8 **OR** 10 **OR** 12, **as directed,** percent.
3. Vane Directional Control: Manual, **OR** Motorized operator, **as directed**.
4. Traversing Control: Manual **OR** Motorized operator, **as directed**.
5. Draw and Stack Position: One way, controls and stack left **OR** One way, controls and stack right **OR** One way, controls left and stack opposite **OR** One way, controls right and stack opposite **OR** Center split, controls left **OR** Center split, controls right **OR** Center stack, controls left **OR** Center stack, controls right **OR** Off center, controls left **OR** Off center, controls right **OR** As indicated on Drawings **OR** As indicated, **as directed**.
6. Cord-Tensioner Mounting: Wall **OR** Floor **OR** Sill **OR** Baseboard **OR** As indicated, **as directed**.
7. Valance: One **OR** Two-tiered, **as directed,** vane insert; with dust cover.
   a. Finish Color Characteristics: Match color, texture, pattern, and gloss of vanes **OR** Color, texture, pattern, and gloss differing from vanes as indicated by manufacturer's designations **OR** Color, texture, pattern, and gloss differing from vanes matching samples **OR** Color texture, pattern, and gloss differing from vanes as selected from manufacturer's full range, **as directed**.
8. Louver Bottom: Connecting or spacing chains.

9. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
10. Stack Release: Permitting stacked vanes to be moved away from stacking position for total access to glazed opening.
11. Colors, Textures, Patterns, and Gloss: As selected from manufacturer's full range.

C. Vertical Louver Blinds, PVC Vanes With Fabric Vane Inserts
1. Rail System: Headrail **OR** Dual system with headrail and bottom rail, **as directed**.
   a. Rails: Extruded aluminum **OR** Formed steel **OR** Manufacturer's standard, **as directed**; long edges returned or rolled; channel-shaped, enclosing operating mechanisms.
      1) Color: Custom color **OR** As selected from manufacturer's standard color range, **as directed**.
      2) Anodized aluminum, clear **OR** color, **as directed,** anodized.
2. Vanes: Lead-free, UV-stabilized, permanently flexible, extruded PVC that will not crack or yellow; with not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed. Provide integrally colored, opaque vane with clear grooves for holding fabric insert.
   a. Nominal Vane Width: 3-1/2 inches (89 mm).
   b. Fabric Insert: Manufacturer's standard; stain and fade resistant.
3. Vane Directional Control: Manual **OR** Motorized operator, **as directed**.
4. Traversing Control: Manual **OR** Motorized operator, **as directed**.
5. Draw and Stack Position: One way, controls and stack left **OR** One way, controls and stack right **OR** One way, controls left and stack opposite **OR** One way, controls right and stack opposite **OR** Center split, controls left **OR** Center split, controls right **OR** Center stack, controls left **OR** Center stack, controls right **OR** Off center, controls left **OR** Off center, controls right **OR** As indicated, **as directed**.
6. Cord-Tensioner Mounting: Wall **OR** Floor **OR** Sill **OR** Baseboard **OR** As indicated on Drawings, **as directed**.
7. Valance: One **OR** Two-tiered, **as directed,** vane insert; with dust cover. Fabric vane insert matching vanes.
8. Louver Bottom: Connecting or spacing chains.
9. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
10. Stack Release: Permitting stacked vanes to be moved away from stacking position for total access to glazed opening.
11. Fabric Colors, Textures, and Patterns: As selected from manufacturer's full range.

D. Vertical Louver Blinds, Fabric Vanes
1. Rail System: Headrail **OR** Dual system with headrail and bottom rail, **as directed**.
   a. Rails: Extruded aluminum **OR** Formed steel **OR** Manufacturer's standard, **as directed**; long edges returned or rolled; channel-shaped, enclosing operating mechanisms.
      1) Color: Custom color **OR** As selected from manufacturer's standard color range, **as directed**.
      2) Anodized aluminum, clear **OR** color, **as directed** anodized.
2. Vanes: Manufacturer's standard **OR** PVC-coated fiberglass mesh **OR** PVC-coated polyester mesh, **as directed,** freehanging fabric with hemmed, nonraveling edges; stain and fade resistant; with not less than 3/8-inch (9.5-mm) overlap when vanes are rotated fully closed.
   a. Nominal Vane Width: 2 inches (51 mm) **OR** 3-1/2 inches (89 mm) **OR** 5 inches (125 mm), **as directed**.
3. Vane Directional Control: Manual.
4. Vane Directional Control: Motorized operator.
5. Traversing Control: Manual.
6. Traversing Control: Motorized operator.
7. Draw and Stack Position: One way, controls and stack left **OR** One way, controls and stack right **OR** One way, controls left and stack opposite **OR** One way, controls right and stack opposite **OR** Center split, controls left **OR** Center split, controls right **OR** Center stack, controls left **OR** Center

stack, controls right **OR** Off center, controls left **OR** Off center, controls right **OR** As indicated, **as directed**.

8. Cord-Tensioner Mounting: Wall **OR** Floor **OR** Sill **OR** Baseboard **OR** As indicated, **as directed**.
9. Valance: One **OR** Two-tiered, **as directed,** vane insert; with dust cover. Fabric vane insert matching vanes.
10. Louver Bottom: Connecting or spacing chains **OR** Weights, **as directed**.
11. Mounting: Wall mounting **OR** Ceiling mounting **OR** End mounting **OR** Wall extension brackets **OR** As indicated, **as directed**.
12. Stack Release: Permitting stacked vanes to be moved away from stacking position for total access to glazed opening.
13. Fabric Colors, Textures, and Patterns: As selected from manufacturer's full range.

E. Vertical Louver Blind Fabrication

1. Product Description: Vertical louver blind consisting of equally spaced, synchronized vanes and rail system with self-aligning carrier mechanisms, carriers, traverse and vane directional mechanisms and controls, and installation hardware.
2. Concealed Components: Noncorrodible or corrosion-resistant-coated materials.
   a. Louver Directional and Traversing Control Mechanisms: With permanently lubricated moving parts.
3. Unit Sizes: Obtain units fabricated in sizes to fill window and other openings as follows:
   a. Blind Units Installed between (inside) Jambs: Width equal to 1/4 inch (6 mm) per side or 1/2 inch (13 mm) total less than jamb-to-jamb dimension of opening in which each blind is installed. Length equal to 1/4 inch (6 mm), plus or minus 1/8 inch (3.1 mm), less than head-to-sill dimension of opening in which each blind is installed.
   b. Blind Units Installed outside Jambs: Width and length as indicated, with terminations between blinds of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.
4. Installation Brackets: Designed for easy removal and reinstallation of blind, for supporting headrail, valance, and operating hardware, and for hardware position and blind mounting method indicated.
5. Installation Fasteners: No fewer than two fasteners per bracket, fabricated from metal noncorrosive to blind hardware and adjoining construction; type designed for securing to supporting substrate; and supporting blinds and accessories under conditions of normal use.
6. Color-Coated Finish: For metal components exposed to view, unless anodized or plated finish is indicated. Apply manufacturer's standard baked finish complying with manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness.
7. Component Color: Provide cords and exposed-to-view metal and plastic matching or coordinating with vane color, unless otherwise indicated.

F. Motorized Vertical Louver Blind Operators

1. General: Provide factory-assembled blind operation systems designed for blind type, size, weight, construction, use, and operation frequency indicated, with traverse **OR** rotation **OR** traverse and rotation, **as directed** functions. Provide operation systems of size and capacity and with features, characteristics, and accessories suitable for Project conditions and recommended by blind manufacturer, complete with electric motors and factory-prewired motor controls, remote-control stations, remote-control devices, power disconnect switches, enclosures protecting controls and all operating parts, headrail, and accessories required for reliable operation without malfunction. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with the building electrical system.
2. Comply with NFPA 70.
3. Control Equipment: Comply with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6 with NFPA 70, Class 2 control circuit, maximum 24-V ac or dc.
4. Electric Motors: UL-approved or -recognized, totally enclosed, insulated motor, complying with NEMA MG 1, with thermal-overload protection and internal limit switches; sized by blind

manufacturer to start and operate size and weight of blind considering service factor or Project's service conditions without exceeding nameplate ratings.

a. Service Factor: According to NEMA MG 1, unless otherwise indicated.

b. Motor Characteristics: Single phase, 24 **OR** 110 **OR** 220, **as directed,** V, 60 Hz.

c. Motor Mounting: On top of **OR** Behind, **as directed,** track, left **OR** right, **as directed,** side of headrail.

d. Motor Mounting: As indicated.

5. Remote Controls: Electric controls with NEMA ICS 6, Type 1 enclosure for surface **OR** recessed or flush **OR** within headrail, **as directed,** mounting. Provide the following devices for remote-control activation of blinds:

a. Control Stations: Keyed, maintained **OR** momentary, **as directed,**-contact, three-position, switch-operated control station with open, close, and off functions. Provide two keys per station.

b. Control Stations: Maintained **OR** Momentary, **as directed,**-contact, three-position, toggle **OR** rocker, **as directed,**-style, wall-switch-operated control station with open, close, and center off functions.

1) Color: Ivory **OR** White **OR** As indicated, **as directed**.

6. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop blind at fully traversed, rotated closed and fully retracted, rotated open positions.

7. Operating Features: **<Insert feature.>**

8. Accessories:

a. Solar Power Unit: For use with control system indicated.

1.3 EXECUTION

A. Installation

1. Install vertical louver blinds level and plumb and aligned with adjacent units according to manufacturer's written instructions, and located so exterior vane edges in any position are not closer than 2 inches (51 mm) to interior face of glass. Install intermediate support as required to prevent deflection in headrail. Allow clearances between adjacent blinds and for operating glazed opening's operation hardware, if any.

2. Flush Mounted: Install vertical louver blinds with vane edges flush with finish face of opening when vanes are tilted open.

3. Jamb Mounted: Install headrail flush with face of opening jamb and head.

4. Head Mounted: Install headrail on face of opening head.

5. Recessed: Install headrail concealed within blind pocket.

6. Connections: Connect motorized operators to building electrical system.

7. Adjust vertical louver blinds to operate smoothly, easily, safely and free of binding or malfunction throughout entire operational range.

8. Clean vertical louver blind surfaces after installation, according to manufacturer's written instructions.

END OF SECTION 12210a

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SECTION 12210b - ROLLER SHADES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for roller shades. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes roller shades and motorized shade operators.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, details of installation, operational clearances, wiring diagrams, and relationship to adjoining Work.
   a. Verify dimensions by field measurements before fabrication and indicate measurements on Shop Drawings.
3. Samples: For each exposed finish and for each color and texture required.
4. Window Treatment Schedule: Use same designations indicated on Drawings.
5. Maintenance data.

D. Quality Assurance
1. Fire-Test-Response Characteristics: Provide products passing flame-resistance testing according to NFPA 701 by a testing agency acceptable to authorities having jurisdiction.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with WCMA A 100.1.

E. Delivery, Storage, And Handling
1. Deliver shades in factory packages, marked with manufacturer and product name, fire-test-response characteristics, lead-free designation, and location of installation using same designations indicated on Drawings and in a window treatment schedule.

1.2 PRODUCTS

A. Roller Shades
1. Shade Band Material: PVC-coated fiberglass **OR** PVC-coated polyester **OR** PVC-coated fiberglass and polyester blends **OR** Fiberglass and acrylic blend **OR** Metallized film **OR** Mirror film **OR** Tinted film **OR** Owner-furnished material, **as directed**.
   a. Colors: Match samples **OR** As selected from manufacturer's full range **OR** As indicated in a window treatment schedule, **as directed**.
   b. Material Solar-Optical Properties: **As directed.**
   c. Material Openness Factor: **As directed** percent.
   d. Material UV Blockage: **As directed** percent.
2. Rollers: Electrogalvanized or epoxy primed steel or extruded-aluminum tube of diameter and wall thickness required to support and fit internal components of operating system and the weight and width of shade band material without sagging; designed to be easily removable from support brackets. Provide capacity for one **OR** two, **as directed**, roller shade band(s) per roller.

3. Direction of Roll: Regular, from back of roller **OR** Reverse, from front of roller **OR** Regular, from back of roller, and reverse, from front of roller, as indicated on Drawings for double-roller shades, **as directed**.
4. Mounting Brackets: Galvanized or zinc-plated steel **OR** Fascia end caps, fabricated from steel finished to match fascia or headbox, **as directed**.
5. Fascia: L-shaped, formed-steel sheet or extruded aluminum; long edges returned or rolled; continuous panel concealing front and bottom of shade roller, brackets, and operating hardware and operators; removable design for access.
6. Top/Back Cover: L-shaped; material and finish to match fascia; combining with fascia and end caps to form a six-sided headbox enclosure sized to fit shade roller and operating hardware inside.
7. Pocket-Style Headbox: U-shaped, formed-steel sheet or extruded aluminum; long edges returned or rolled; with a bottom cover consisting of slot opening of minimum dimension to allow lowering and raising of shade and a removable or an openable, continuous metal access panel concealing shade roller, brackets, and operating hardware and operators within.
8. Pocket with Ceiling Slot Opening: Six-sided box units for recessed installation; fabricated from formed-steel sheet, extruded aluminum, or wood; with a bottom consisting of slot opening of minimum dimension to allow lowering and raising of shade and a removable or an openable, continuous metal access panel concealing rollers, brackets, and operating hardware and operators within.
   a. Corner Section: Factory formed and welded.
9. Bottom Bar: Steel or extruded aluminum, with plastic or metal capped ends. Provide exposed-to-view, external **OR** concealed, by pocket of shade material, internal, **as directed**,-type.
10. Audiovisual Light-Blocking Shades: Designed for eliminating all visible light gaps when shades are fully closed; fabricated from blackout shade band material with fascia **OR** headbox **OR** pocket, **as directed**, and bottom bar extended and formed for light-tight joints among shade components and between shade components and adjacent construction.
11. Skylight Shades: Manufacturer's complete system for operable skylight shades, including operator, operating hardware, and accessories for smooth operation, designed for installation in horizontal position **OR** inclined position, slope as indicated on Drawings, **as directed**.
12. Valance: As indicated by manufacturer's designation for style and color **OR** Style matching hem; as indicated by manufacturer's designation color **OR** As indicated in a window treatment schedule, **as directed**.
13. Mounting: Inside **OR** Outside **OR** Ceiling **OR** Recessed in ceiling pocket **OR** Wall extension brackets **OR** Bottom-up brackets **OR** As indicated on Drawings, **as directed**.
14. Shade Operation: Manual; with spring roller **OR** continuous-loop bead-chain, clutch, and cord tensioner and bracket **OR** gear and crank **OR** cordless system, **as directed**, lift operator.
15. Hold-Down Brackets and Hooks or Pins and Side Channels: Manufacturer's standard for fixing shade in place, keeping shade band material taut, and reducing light gaps when shades are closed.
16. Shade Operation: Manual; with spring roller **OR** continuous-loop bead-chain, clutch, and cord tensioner and bracket **OR** gear and crank **OR** cordless system, **as directed**, lift operator.

B. Roller Shade Fabrication
1. Unit Sizes: Obtain units fabricated in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):
   a. Shade Units Installed between (Inside) Jambs: Edge of shade not more than 1/4 inch (6 mm) from face of jamb. Length equal to head to sill dimension of opening in which each shade is installed.
   b. Shade Units Installed Outside Jambs: Width and length as indicated, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.
2. Installation Brackets: Designed for easy removal and reinstallation of shade, for supporting fascia, headbox, roller, and operating hardware and for hardware position and shade mounting method indicated.

3. Installation Fasteners: No fewer than two fasteners per bracket, fabricated from metal noncorrosive to shade hardware and adjoining construction; type designed for securing to supporting substrate; and supporting shades and accessories under conditions of normal use.

C. Motorized Roller Shade Operators
1. General: Provide factory-assembled motorized shade operation systems designed for lifting shades of type, size, weight, construction, use, and operation frequency indicated. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with the building electrical system.
2. Comply with NFPA 70.
3. Control Equipment: Comply with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6 with NFPA 70, Class 2 control circuit, maximum 24-V ac or dc.
4. Electric Motors: UL-approved or -recognized, totally enclosed, insulated motor, complying with NEMA MG 1, with thermal-overload protection, brake, permanently lubricated bearings, and limit switches; sized by shade manufacturer to start and operate size and weight of shade considering service factor or considering Project's service conditions without exceeding nameplate ratings.
   a. Service Factor: According to NEMA MG 1, unless otherwise indicated.
   b. Motor Characteristics: Single phase, 24 **OR** 110 **OR** 220, **as directed**, V, 60 Hz.
   c. Motor Mounting: Within manufacturer's standard roller enclosure.
5. Remote Controls: Electric controls with NEMA ICS 6, Type 1 enclosure surface **OR** recessed or flush, **as directed,** mounting. Keyed switch **OR** Toggle-style, wall switch Rocker-style, wall switch **OR** Rocker-style, group-control wall switch **OR** Rocker-style, individual/group-control wall switch **OR** Sun sensor **OR** Radio **OR** Infrared **OR** Timer **OR** Microprocessor, **as directed**.
6. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop shade at fully raised and fully lowered positions.

1.3 EXECUTION

A. Roller Shade Installation
1. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions, and located so shade band is not closer than 2 inches (50 mm) to interior face of glass. Allow clearances for window operation hardware.
2. Connections: Connect motorized operators to building electrical system.
3. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.
4. Clean roller shade surfaces after installation, according to manufacturer's written instructions.

END OF SECTION 12210b

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SECTION 12210c - PLEATED SHADES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for pleated shades. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following types of horizontal-fold shades and accessories:
   a. Z-pleated shades.
   b. Cellular shades.
   c. Motorized shade operators.

C. Definitions
1. Cellular Shades: Pleated shades with more than one horizontally folded fabric layer forming accordion-folded fabric with enclosed air spaces or cells. Cellular shades may consist of two fabric layers forming a continuous accordion fold of enclosed air spaces or cells for a linear row of cells, one cell wide; three fabric layers forming two interconnected accordion folds of enclosed air spaces or cells for two honeycombed rows of cells, nominally two cells wide; or four fabric layers forming three interconnected accordion folds of enclosed air spaces or cells for three honeycombed rows of cells, nominally three cells wide.
2. Pleated Shades: Permanently creased, horizontally folded shades. Alternatively, pleated shades are synonymous with Z-pleated shades according to the industry. Z-pleated shades consist of one fabric layer forming Z-folded pleats.

D. Submittals
1. Product Data: For each type of product indicated.
   a. Motorized Shade Operators: Include operating instructions.
   b. Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.
2. Shop Drawings: Show location and extent of pleated shades. Include elevations, sections, details, and dimensions not shown in Product Data. Show installation details, mountings, attachments to other work, operational clearances, and relationship to adjoining work.
   a. Motorized Shade Operators: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
   b. Wiring Diagrams: Power, system, and control wiring.
3. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   a. Suspended ceiling components.
   b. Structural members to which equipment **OR** suspension systems, **as directed**, will be attached.
   c. Sizes and locations of initial access modules for acoustical tile.
   d. Items penetrating finished ceiling, including the following:
      1) Lighting fixtures.
      2) Air outlets and inlets.
      3) Speakers.
      4) Sprinklers.
      5) Access panels.
   e. Perimeter moldings.
4. Samples: For the following products:

a. Shade Fabrics: Not less than 3 inches (76 mm) square, with specified treatments applied. Mark face of material.
b. Valance: Full-size unit, not less than 12 inches (300 mm) long.

5. Maintenance Data.

E. Quality Assurance
1. Fire-Test-Response Characteristics: Provide pleated shades with the fire-test-response characteristics indicated, as determined by testing identical products per test method indicated below by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency:
a. Flame-Resistance Ratings: Passes NFPA 701.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Product Standard: Provide pleated shades complying with WCMA A 100.1.

F. Delivery, Storage, And Handling
1. Deliver shades in factory packages, marked with manufacturer and product name, fire-test-response characteristics, **OR** lead-free designation, **as directed**, and location of installation using same designations indicated on Drawings and in a window treatment schedule.

1.2 PRODUCTS

A. Z-Pleated Shades
1. Z-Pleated Shade Construction: One-fabric thickness, with uniform pleat spacing maintained at all positions.
a. Nominal Pleat Width: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (76 mm) **OR** 4 inches (100 mm), **as directed**.
2. Shade Fabric: Manufacturer's standard **OR** 100 percent nonwoven polyester with antistatic treatment **OR** PVC-coated polyester mesh **OR** 100 percent spun-woven polyester, **as directed**; stain and fade resistant, width as wide as required for seamless shade.
a. Fabric Width: 36 inches (910 mm) **OR** 48 inches (1220 mm) **OR** 60 inches (1520 mm) **OR** 72 inches (1830 mm) **OR** 84 inches (2130 mm) **OR** 96 inches (2440 mm) **OR** As indicated on Drawings **OR** As indicated in a window treatment schedule, **as directed**.
b. Pattern: as directed by the Owner.
c. Style: as directed by the Owner.
d. Colors: Match samples **OR** As selected from manufacturer's full range **OR** As indicated in a window treatment schedule, **as directed**.
e. **Material Solar-Optical Properties: as directed by the Owner.**
f. Material Openness Factor: percent as directed by the Owner..
g. Material UV Blockage: percent as directed by the Owner..
3. Headrail: Formed steel or extruded aluminum; long edges returned or rolled; fully enclosing operating mechanisms on three sides and ends; capacity for one **OR** two, **as directed**, shade(s) per headrail, unless otherwise indicated on Drawings **OR** in a window treatment schedule, **as directed**.
4. Bottom Rail: Formed-steel or extruded-aluminum tube, sealed with plastic or metal capped ends.
5. Valance: Clear plastic with fabric insert matching fabric shade.
6. R-Value: Not less than 2.22 deg F x h x sq. ft./Btu (0.39 K x sq. m/W) **OR** 4.8 deg F x h x sq. ft./Btu (0.85 K x sq. m/W), **as directed**.
7. Mounting: Wall **OR** Ceiling **OR** End **OR** Wall extension brackets **OR** As indicated on Drawings, **as directed**, mounting permitting easy removal and replacement without damaging shade or adjacent surfaces and finishes; with spacers and shims required for shade placement and alignment indicated.

8. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard, as indicated.
9. Side Channels and Perimeter Seals: Manufacturer's standard for eliminating light gaps when shades are closed.
10. Shade Operation: Manual.
    a. Lift Control: System including lift cord, crash-proof cord lock, and cord joiner ball **OR** System including continuous-cord loop, clutch, and cord tensioner and bracket **OR** Cordless system, **as directed**, designed to hold shade in place unless force is applied to move shade.
    b. Length of Lift Cord **OR** Cord Loop, **as directed**: Manufacturer's standard length **OR** Full length of shade **OR** Length required to make operation convenient from floor level **OR** As indicated on Drawings, **as directed**.
    c. Position of Lift Cord **OR** Cord Loop, **as directed**: As indicated on Drawings **OR** in a window treatment schedule, **as directed**.
    d. Position of Lift Cord **OR** Cord Loop, **as directed**: Left side **OR** Right side **OR** Left end **OR** Right end, **as directed**, of headrail, unless otherwise indicated on Drawings **OR** in a window treatment schedule, **as directed**.
    e. Cord Tensioner Mounting: Wall **OR** Floor **OR** Sill **OR** Baseboard **OR** As indicated on Drawings, **as directed**.
11. Shade Operation: Motorized operator.

B. Cellular Shades
1. Cellular Shade Construction: Two-fabric thicknesses and one row of cells, one cell wide.
    a. Nominal Cell Width: 3/8 to 7/16 inch (10 to 11 mm) **OR** 1/2 inch (13 mm) **OR** 9/16 inch (14.2 mm) **OR** 3/4 inch (19 mm), **as directed**.
2. Cellular Shade Construction: Three-fabric thicknesses and two honeycombed cells, nominally two cells wide.
    a. Nominal Cell Width: 3/8 inch (10 mm).
3. Cellular Shade Construction: Four-fabric thicknesses and three honeycombed cells, nominally three cells wide.
    a. Nominal Cell Width: 3/8 inch (10 mm).
4. Shade Fabric: Manufacturer's standard **OR** 100 percent nonwoven polyester with antistatic treatment **OR** 100 percent spun-woven polyester, **as directed**; stain and fade resistant, width as wide as required for seamless shade.
    a. Fabric Width: 36 inches (910 mm) **OR** 48 inches (1220 mm) **OR** 60 inches (1520 mm) **OR** 72 inches (1830 mm) **OR** 84 inches (2130 mm) **OR** 96 inches (2440 mm) **OR** As indicated on Drawings **OR** As indicated in a window treatment schedule, **as directed**.
    b. Pattern: as directed by the Owner.
    c. Style: as directed by the Owner.
    d. Colors: Match samples **OR** As selected from manufacturer's full range **OR** As indicated in a window treatment schedule, **as directed**.
5. Headrail: Formed steel or extruded aluminum; long edges returned or rolled; fully enclosing operating mechanisms on three sides and ends; capacity for one **OR** two, **as directed**, shade(s) per headrail, unless otherwise indicated on Drawings **OR** in a window treatment schedule, **as directed**.
6. Bottom Rail: Formed-steel or extruded-aluminum tube, sealed with plastic or metal capped ends.
7. Valance: Clear plastic with fabric insert matching fabric shade.
8. R-Value: Not less than 2.22 deg F x h x sq. ft./Btu (0.39 K x sq. m/W) **OR** 4.8 deg F x h x sq. ft./Btu (0.85 K x sq. m/W), **as directed**.
9. Mounting: Wall **OR** Ceiling **OR** End **OR** Wall extension brackets **OR** As indicated on Drawings, **as directed**, mounting permitting easy removal and replacement without damaging shade or adjacent surfaces and finishes; with spacers and shims required for shade placement and alignment indicated.
10. Hold-Down Brackets and Hooks or Pins: Manufacturer's standard, as indicated.
11. Side Channels and Perimeter Seals: Manufacturer's standard for eliminating light gaps when shades are closed.
12. Shade Operation: Manual.

a. Lift Control: System including lift cord, crash-proof cord lock, and cord joiner ball **OR** System including continuous-cord loop, clutch, and cord tensioner and bracket **OR** Cordless system, **as directed**, designed to hold shade in place unless force is applied to move shade.
b. Length of Lift Cord **OR** Cord Loop, **as directed**: Manufacturer's standard length **OR** Full length of shade **OR** Length required to make operation convenient from floor level **OR** As indicated on Drawings, **as directed**.
c. Position of Lift Cord **OR** Cord Loop, **as directed**: As indicated on Drawings **OR** in a window treatment schedule, **as directed**.
d. Position of Lift Cord **OR** Cord Loop, **as directed**: Left side **OR** Right side **OR** Left end **OR** Right end, **as directed**, of headrail, unless otherwise indicated on Drawings **OR** in a window treatment schedule, **as directed**.
e. Cord Tensioner Mounting: Wall **OR** Floor **OR** Sill **OR** Baseboard **OR** As indicated on Drawings, **as directed**.

13. Shade Operation: Motorized operator.

C. Pleated Shade Fabrication

1. Product Description: Pleated shades each consisting of fabric, rails, ladders, lifting mechanism, self-leveling device, and installation hardware.
2. Concealed Components: Noncorrodible or corrosion-resistant-coated materials.
   a. Lifting Mechanism: With permanently lubricated moving parts.
3. Unit Sizes: Obtain units fabricated in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):
   a. Shade Units Installed between (Inside) Jambs: Edge of shade not more than 1/4 inch (6 mm) from face of jamb. Length equal to head-to-sill dimension of opening in which each shade is installed.
   b. Shade Units Installed Outside Jambs: Width and length as indicated, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.
4. Installation Brackets: Designed for easy removal and reinstallation of shade, for supporting headrail, valance, **as directed**, and operating hardware and for hardware position and shade mounting method indicated.
5. Installation Fasteners: No fewer than two fasteners per bracket, fabricated from metal noncorrosive to shade hardware and adjoining construction; type designed for securing to supporting substrate; and supporting shades and accessories under conditions of normal use.
6. Color-Coated Finish: For metal components exposed to view, apply manufacturer's standard baked finish complying with manufacturer's written instructions for surface preparation including pretreatment, application, baking, and minimum dry film thickness.
7. Component Color: Provide rails and cords, **as directed**, and exposed-to-view ladders, **as directed**, metal and plastic matching or coordinating with fabric color, unless otherwise indicated.

D. Motorized Pleated Shade Operators

1. General: Provide factory-assembled shade operation systems designed for lifting shades of type, size, weight, construction, use, and operation frequency indicated. Provide operation systems of size and capacity and with features, characteristics, and accessories suitable for Project conditions and recommended by shade manufacturer, complete with electric motors and factory-prewired motor controls, remote-control stations, remote-control devices, power disconnect switches, enclosures protecting controls and all operating parts, headrail, and accessories required for reliable operation without malfunction. Include wiring from motor controls to motors. Coordinate operator wiring requirements and electrical characteristics with the building electrical system.
2. Comply with NFPA 70.
3. Control Equipment: Comply with NEMA ICS 1, NEMA ICS 2, and NEMA ICS 6 with NFPA 70, Class 2 control circuit, maximum 24-V ac or dc, **as directed**.

4. Electric Motors: UL-approved or -recognized, totally enclosed, insulated motor, complying with NEMA MG 1, with thermal-overload protection, brake, permanently lubricated bearings, and internal limit switches; sized by shade manufacturer to start and operate size and weight of shade considering service factor or considering Project's service conditions without exceeding nameplate ratings.
   a. Service Factor: According to NEMA MG 1, unless otherwise indicated.
   b. Motor Characteristics: Single phase, 24 **OR** 110 **OR** 220, **as directed**, V, 60 Hz.
   c. Motor Mounting: Within manufacturer's standard headrail enclosure.
5. Remote Controls: Electric controls with NEMA ICS 6, Type 1 enclosure for surface **OR** recessed or flush **OR** within headrail, **as directed**, mounting. Provide the following devices for remote-control activation of shades:
   a. Control Stations: Keyed, maintained **OR** momentary, **as directed**,-contact, three-position, switch-operated control station with open, close, and off functions. Provide two keys per station.
   b. Control Stations: Maintained **OR** Momentary, **as directed**,-contact, three-position, toggle **OR** rocker, **as directed**,-style, wall switch-operated control station with open, close, and center off functions.
      1) Color: Ivory **OR** White **OR** As indicated in a window treatment schedule, **as directed**.
   c. Group Control Stations: Maintained **OR** Momentary, **as directed**,-contact, three-position, rocker-style, wall switch-operated control station with open, close, and center off functions for single-switch group control.
      1) Color: Ivory **OR** White **OR** As indicated in a window treatment schedule, **as directed**.
   d. Individual/Group Control Stations: Maintained **OR** Momentary, **as directed**,-contact, three-position, rocker-style, wall switch-operated control station with open, close, and center-off functions for individual and group control.
      1) Color: Ivory **OR** White **OR** As indicated in a window treatment schedule, **as directed**.
   e. Sun Sensor Controls: Programmable system activated by LEDs detecting daylight intensity and responding by automatically adjusting shades.
   f. Radio Controls: Digital system consisting of code-compatible universal coaxial receiver, one per shade **OR** one per headrail **OR** where indicated on Drawings, **as directed**, and two, **as directed**, portable, multiple-channel transmitters for operating two **OR** four **OR** up to 12, **as directed**, shades individually, each with a single button to open and close shades.
   g. Infrared Controls: System consisting of concealed receiver complete with external eye and connecting modular cable, and two, **as directed**, portable, multiple-channel transmitters with separate buttons to open and close up to 12, **as directed**, individual shades or groups of shades, to open and close all shades simultaneously, and to stop.
   h. Timer Controls: Clock timer, 24-hour **OR** seven-day, **as directed**, programmable for regular events.
   i. Microprocessor Controls: Electronic programmable means for setting, changing, and adjusting control features. Provide unit isolated from voltage spikes and surges.
6. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop shade at fully raised and fully lowered positions.
7. Operating Features: Include the following:
   a. Group switching with integrated switch control; one face plate for multiple switch cut-outs.
   b. Capable of interface with audiovisual **OR** multiroom, **as directed**, control system.
   c. Capable of accepting input from building automation control system.
   d. Override switch.
8. Accessories: Include the following:
   a. Solar Power Unit: For use with control system indicated.
9. Headrail: Manufacturer's standard formed steel or extruded aluminum; long edges returned or rolled; fully enclosing operating mechanisms on three sides and ends; capacity for one **OR** two,

as directed, shade(s) per headrail, unless otherwise indicated on Drawings **OR** in a window treatment schedule, **as directed**.

a. Color: Match shade **OR** As indicated by manufacturer's designations **OR** As selected from manufacturer's full range **OR** As indicated in a window treatment schedule, **as directed**.

1.3 EXECUTION

A. Pleated Shade Installation

1. Install shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions, and located so pleat edges are not closer than 2 inches (50 mm) to interior face of glass. Install intermediate support as required to prevent deflection in headrail. Allow clearances for window operation hardware.
2. Flush Mounted: Install shades with pleat edges flush with finish face of opening if shade is in fully lowered position.
3. Jamb Mounted: Install headrail flush with face of opening jamb and head.
4. Head Mounted: Install headrail on face of opening head.
5. Recessed: Install headrail concealed within shade pocket.
6. Connections: Connect motorized operators to building electrical system.

B. Adjusting

1. Adjust and balance pleated shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

C. Cleaning And Protection

1. Clean pleated shade surfaces after installation, according to manufacturer's written instructions.
2. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that pleated shades are without damage or deterioration at time of Substantial Completion.
3. Replace damaged pleated shades that cannot be repaired, in a manner approved, before time of Substantial Completion.

END OF SECTION 12210c

SECTION 12315 - KITCHEN CASEWORK, STAINLESS STEEL CABINETS

1.1 GENERAL

A. Description of Work
1. This specification covers the furnishing and installation of materials for kitchen casework, stainless steel cabinets. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Quality Assurance
1. Comply with all provisions of specifications for the design, quality testing. Manufacturing and installation of metal kitchen cabinets and specified equipment.
2. All kitchen cabinetry and equipment herein specified and shown on the drawings shall meet the standards, quality of materials, construction, workmanship and finish of Innovative Laboratory Systems Co., 1336 Industrial Rd., Omaha Nebraska, (402) 333-0679. Equal manufacturers acceptable.
3. All metal cabinetry and equipment herein shall be the product of one manufacturer and be the one on which this specification is based or approved of substitutes must be obtained in writing from the City of Chicago Purchasing Department ten days prior to the bid due date. All manufacturers other than the specified product shall provide evidence of having a minimum of five years experience in the manufacturing and installation of stainless steel kitchen cabinetry.
4. The manufacturer shall, from one year to date of installation, warrant parts or products manufactured and finished against manufacturing defects in material and any such parts which under normal use prove defective within one year form date of installation, shall be repaired or replaced without charge to the Owner.
5. Wood shall not be used in any portion of the casework construction whether exposed or hidden from view.

C. Submittals
1. Shop Drawings
   a. Identify location of metal cabinetry and related items.
   b. Detail cabinets, shelving, countertops, etc, in related and dimensional position, with sections. Locations for roughing-in of plumbing, including sinks, faucets, strainers, cocks, etc. shall be included
2. Certificates: All bidders shall provide to the Owner independent test results from a nationally recognized testing laboratory on the finishes required for this project with the bid.

1.2 PRODUCTS

A. Material
1. All metal cabinetry shall be fabricated to Type 304 stainless steel free of scales buckles or other defects.
2. Minimum metal gauge: All minimum thickness of metal referred to herein shall be U.S. standard gauge.
   a. 20 Gauge: Inner door panels, inner and outer drawer panels, drawer body, and shelves.
   b. 18 Gauge: Outer door panels, sides, backs, bottoms, and tops.
   c. 16 Gauge: Top rails, cross rails, drawer slides.
   d. 14 Gauge: Leveling and corner gussets.

B. Fabrications
1. Cabinet Grade: Premium and complying with the following.
   a. Align sides, top rails, bottoms and vertical stiles, at intersections, without overlap.

b. Rounded edges.
c. Full welded seams.
d. Grind exposed welds flush and smooth.

2. Cases: The sides of cabinets shall be formed to make a rabbeted stile 1-1/8" wide. Top of case stiles shall be closed by a mitered 45-degree bend from tip of case side. Stiles shall be closed by welded channel, which contains front shelf adjustment louvers. All case members including intermediate cross rails shall be welded for maximum strength. Use of sheet metal screws to hold intermediate cross rails in place is not acceptable. Sides of all cabinets shall be free from any holes to prevent dust and bacteria from entering the cabinet. Pre-punched holes in the side of any cabinet will not be allowed. All drawer cabinets and cupboard cabinets shall have full backs and bottoms welded into place. Any cabinet without any backs or bottoms will be rejected. All interior bottoms of base and tall cabinets shall be turned down to provide a clean, flush interior free from dust catching ledges and preventing bacterial accumulation. Bottoms of all wall units shall be flushed; recessed bottoms are not acceptable.
3. Doors
   a. Doors shall be double panel reinforced construction 5/8" thick and sound deadened with vertical steel battens. Door fronts and liners shall be welded together for added strength. Door fronts and cases shall be slotted to receive hinges. Hinge wings must be concealed when doors open. Wrap around type hinges are not acceptable. All doors shall have soft rubber bumpers for quiet closing. Rubber bumpers must be securely locked in place. Rubber Bumpers attached by adhesives are not acceptable. All corners of doors shall be welded and ground smooth.
   b. Sliding doors shall be double panel reinforced construction 5/8" thick and operate on nylon rollers suspended from stainless steel track at top of unit and center guide at bottom. Sliding doors shall have recessed door pulls.
4. Drawers
   a. Drawers front shall be double panel reinforced construction with 5/8" thick fronts and sound deadened with vertical steel battens. Drawers shall be all welded construction. All drawers shall have soft rubber bumpers for quiet closing. Rubber bumpers must be securely locked in place. Rubber bumpers attached by adhesives are not acceptable. All edges of drawer fronts shall be closed.
   b. Drawer bodies shall be formed from a single sheet of steel including the bottom, two sides, back and inner front. Interior bottoms of drawers shall be fully covered on four sides for ease in cleaning. The top front of the inner drawer shall be offset to interlock with the outer drawer front.
   c. Flanges on the top of drawer body shall be fully formed channel and bent at a 6-degree angle for maximum strength. Flanges shall be formed to leave the inside of the drawer free form sharp edges. Drawer slide shall be welded to drawer body and be part of a "Z" shaped member in a wrap around design to support drawer body. Drawer slides shall have a 15/16" nylon tired ball bearing roller. Drawer slide shall be roller type, positive in action permitting drawer to be fully opened; yet preventing drawer from accidental removal. Case slides shall be a formed piece of galvanized steel with 15/16" nylon tired ball bearing roller at front of slide. All ball bearing rollers for drawer slide and case slide shall be pre-lubricated to guarantee a smooth, quiet operation. All drawers shall rise upward when opened to prevent engaging of drawers and doors below. Drawers shall have self-closing design during the last 5" of travel.
5. Shelves: Shelves shall be formed from a single sheet of stainless steel with 7/8" face turned back and up at a 30-degree angle and edge of flange shall make firm contact with underside of shelf for sound deadening. All shelves in cabinets shall be adjustable on 1-1/2" center and supported by stainless steel clips placed in embossed louvers. All shelves shall be solid.
6. Hardware: Door catch shall be positive type latch located at upper inside edge of door. Stainless steel strike bracket shall be installed inside of door with accessible removable screws. Bolt shall be nylon self-closing type tested for 300,000 opening and closing cycles. Complete bolt housing shall be recessed behind cross rail. Roller catches and/or friction catches are not acceptable.

7. Hinges: Hinges shall be institutional type, 2-1/2" long, with a metal thickness of least 0.090", containing 5-knuckles, and centered 3" above bottom and below top of door. Doors 45" high and over shall have an additional hinge in center. Hinges shall be stainless steel with smooth rounded joints for easy cleaning. When door is closed, only the joint shall be exposed. Both hinge wings shall be encased, one within the door, the other within the case. Hinges shall be attached to the door and the case by screws. Hinges welded to door and/or case are not acceptable.
8. Door and Drawer Pull: Door and drawer pull shall be stainless steel with a brushed satin finish. Shoulder screws shall be used so that when handles are mounted they do not cause the door to buckle or cave. Sliding doors shall have recessed door pulls.
9. Base Cabinet Legs: All base cabinets and sink units shall be furnished with integral stainless steel legs with adjustable levelers. Bottom of base cabinets shall be approximately 6" above the floor.
10. Locking Mechanism: All cabinet doors shall be provided with stainless steel angle hasps, with half-inch diameter holes for pad locking, as shown on the drawings. The left door of each door pair shall have a sliding flush bolt on the inside face, as shown on the drawings, to prevent the pair of doors from swinging open when pad locked.

C. Steel Cabinet Finish
1. Test Procedure: Chemical spot tests shall be made by applying 10 to 15 drops (approximately 0.5 cubic cm) of each reagent listed in Table 1 to the surface to be tested. Each reagent spot shall be open to the atmosphere. Ambient temperature is 68-72 degrees F (20-22 degrees C). After one hour, chemicals shall be flushed away with cold water and the surface, washed with detergent and warm water at 150 degrees F (65 degrees C). Surface shall be examined under 100-foot candles of illumination.

D. Kitchen Cabinets Performance Requirements
1. Base Cabinets.
   a. Cabinets Load Test: A 48" wide standing height combination cupboard and drawer cabinet shall be freestanding with installed counter top. Cabinet shall sit 1" off the floor on all four leveling screws and be capable of supporting a uniform distributed load of 2,000 lbs. Door and drawer operation shall not be affected by the load.
   b. Leveling device for floor mounted cabinets shall be capable of supporting a load of 500 lbs. Without failure and capable of adjustment after load is removed.
   c. Cabinet Door Test: An open door shall withstand a load of 200 lbs. applied directly at the outer edge. Door shall be moved through a 180 degree arc and weight removed. Operation of the door after test shall be normal without distortion that will adversely affect operation for the door catch.
   d. Life Cycle Test.
      1) Door hinge shall operate for 300,000 opening and closing cycles without a failure.
      2) Positive door catch shall operate for 300,000 opening and closing cycles without failure.
      3) Drawer shall be tested and operated with a load of 100 lbs. for a minimum of 150,000 opening and closing cycles. After test, drawers shall operate freely without evidence of dragging or scraping.
2. Wall Cabinets
   a. A 48" wide, 30" high, 12 ¾" deep hinged wall case shall support a load of 1lbs. on cabinet bottom and 100 lbs. on each adjustable shelf for a total of 300 lbs. Cabinet shall not show any significant permanent defection of cabinet, cabinet bottom or shelves. Doors shall operate smoothly when cabinet is fully loaded.
   b. An adjustable shelf shall support a uniformly distributed load of 100 lbs. When load is removed, shelf should show no significant permanent distortion.
   c. Performance of hinge and catch shall be the same as used on base cabinets.

E. Working Surfaces
1. Stainless Steel: Sink and counter tops shall be fabricated of 16 gauge, Type 304, 18-8 solid stainless steel formed down and back making a 1 ½" high face on all exposed edges.

Drainboards and cabinet tops shall be rigidly reinforced the full length of the top. Drainboards shall be two-way pitched to the bowl to provide drainage without channeling or grooving. Drainboards, flanges and splashes shall be integral, being formed from one sheet of metal. Raised edge surrounding unit shall be seamless die formed at front and ends of unit. Sink bowls shall be fabricated of 16 gauge, Type 304, 18-8 solid stainless steel seamless electrically welded to drainboard. All joints shall be electrically welded, ground and polished to a satin finish. Entire units shall be thoroughly sound deadened on under surface with sprayed or trowelled undercoating. Wood shall not be used. All tops shall have stainless steel runners to facilitate fastening to cabinets.

1.3 EXECUTION

A. Insulations
1. Install cabinets, shelves, counter tops and other equipment level and square. Install sink units to provide positive drainage of bottom surface of the sinks.
2. Wall cabinets shall be hung from the metal stud framing system wherever possible. If the wall cabinets must be hung from the wall surfacing at any location, proper anchors shall be used. Install wall cabinets level and aligned.
3. Install base cabinets firmly on ground. Level all the surfaces by adjusting the leg levelers. Attached countertops to inslatted base cabinets with stainless steel screws as required. Caulk with silicone all around counter tops where it interfaces with the existing walls. Install the flat back panels to the wall surfaces by the most appropriate method and caulk as required.
4. All work, including installation of new casework, flooring, ceiling, ductwork, etc., as well as the demolition of the existing casework, flooring, etc. shall be completed within three (3) consecutive days of work start. Hours of work shall be between 7:30 a.m. 9:00 p.m. All work, including work noted on Punch List, shall be completed by 9:00 p.m. of the third work day after work starts.

B. Temporary Work Station
1. During the period of demolition and new casework installation (3 days maximum) the contractor shall provide a temporary cabinet assembly for use by the Owner. The temporary assembly shall have a 6-foot section of cabinets with countertop, sink and faucet. The faucet shall be temporary connected to an apparatus hose bib for providing cold water to the sink. The sink shall be temporarily connected to a sewer line or floor drain if possible for the discharge or to another approved system of temporary discharge by means of a suitable container. For the latter method, the Contractor shall be responsible for periodically disposing of the waste container's contents. The temporary cabinet assembly shall be located reasonably close to the existing kitchens and/or dining areas being remodeled. The Owner shall approve the location of the temporary cabinets.

C. Inspection
1. Inspect installed work of other trades and installation conditions for acceptability. Inform Owner of discrepancies that will jeopardize a complete and proper installation
2. Cleaning: Touching up marred and/or abraded finished surfaces, clean components to post construction accepted levels, remove crating and packing material, broom sweep premises.

END OF SECTION 12315

Task	Specification	Specification Description
12315	01352	No Specification Required

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SECTION 12480 - FOOT GRILLES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for foot grilles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the Work.

B. Summary
1. This Section includes recessed foot grilles and frames.

C. Performance Requirements
1. Structural Performance: Provide foot grilles and frames capable of withstanding the following loads and stresses:
a. Uniform floor load of 300 lbf/sq. ft. (14.36 kN/sq. m) **OR as directed**.
b. Wheel load of 350 lb (159 kg) **OR as directed,** per wheel.

D. Submittals
1. Product Data: For each type of foot grille and frame.
2. Shop Drawings: Show the following:
a. Items penetrating foot grilles and frames, including the following:
1) Door control devices.
b. Divisions between grille sections.
c. Perimeter floor moldings.
3. Samples: For each type of product involving color selection.
a. Foot Grille: 12-inch- (300-mm-) square assembled sections.
b. Frame Members: 12-inch- (300-mm-) long Sample of each type and color.
4. Maintenance data.

E. Quality Assurance
1. Accessibility Requirements: Provide installed foot grilles that comply with Section 4.5 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** Sections 302 and 303 in ICC A117.1., **as directed**

1.2 PRODUCTS

A. Materials
1. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, Commercial Steel (CS), Type B, with A60 (ZF180) zinc-iron-alloy (galvannealed) coating or with G60 (Z180) mill-phosphatized zinc coating; stretcher-leveled standard of flatness; with minimum thickness indicated representing specified thickness according to ASTM A 924/A 924M.
2. Stainless-Steel Sheet, Strip, Plate, and Flat Bars: ASTM A 666, Type 304.
3. Aluminum Sheet: ASTM B 209 (ASTM B 209M), alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than strength and durability properties of Alloy 5005-H15.
4. Extruded Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6061-T6 or Alloy 6063-T5, T6, or T52 as standard with manufacturer. Coat surface of frame in contact with cementitious materials with manufacturer's standard protective coating.
5. Extruded Architectural Bronze: ASTM B 455, Alloy No. C38500.
6. Stainless-Steel Angles: ASTM A 276 or ASTM A 479/A 479M, corrosion resistant, Type 304.

B. Foot Grilles
1. General: Provide manufacturer's standard foot-grille assemblies consisting of treads of type and profile indicated, interlocked or joined together by cross members, and with support legs (if any) and other components needed to produce a complete installation.
2. Aluminum **OR** Bronze, **as directed**, Foot Grilles: Provide manufacturer's standard foot grilles with extruded members, top-surfaced tread rails, and as follows:
   a. Tread Rails: Extruded-aluminum **OR** Extruded-bronze, **as directed**, tread rails with extruded-aluminum frame, **as directed**.
   b. Tread Rail Spacing: 1-1/2 inches (38 mm) o.c. with 1/8- to 3/16-inch- (3- to 4.8-mm-) **OR** 2 inches (50 mm) o.c. with 1/4-inch- (6-mm-), **as directed**, wide openings between treads.
   c. Aluminum Finish: Mill **OR** Anodized, **as directed**.
      1) Colors: Clear natural aluminum **OR** Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from manufacturer's full range, **as directed**.
   d. Top Surface: Serrated aluminum **OR** Serrated bronze **OR** Serrated vinyl cap with UV stabilizer and antifungal additive **OR** Textured-surface, resilient vinyl insert **OR** Aluminum-oxide or silicon-carbide grit in epoxy matrix **OR** Abrasive particles bonded to or imbedded in vinyl insert **OR** Fusion-bonded, level-cut-pile nylon carpet insert; 1/4 inch (6 mm) high, 28 oz./sq. yd. (950 g/sq. m), **as directed**.
      1) Colors: As selected from manufacturer's full range, **as directed**.
   e. Grille Size: As indicated **OR as directed**.
3. Stainless-Steel Foot Grille: Type 304.
   a. Surface Treads: 0.071-by-0.177-inch (1.8-by-4.49-mm) wire with 0.125-inch- (3.17-mm-) **OR** 0.090-by-0.172-inch (2.2-by-4.37-mm) wire with 0.145-inch- (3.68-mm-) **OR** 0.093-by-0.156-inch (2.36-by-3.96-mm) wire with 0.125-inch- (3.17-mm-), **as directed**, wide openings between wires.
   b. Support Rods: Spaced 1 inch (25 mm) o.c., welded to each wire.
   c. Mat Grating: 5/8 inch (16 mm) deep.
   d. Pit Grating: 1-1/8 inches (28.5 mm) deep.
   e. Stainless-Steel Finish: Mill **OR** No. 4, **as directed**, finish.
   f. Grille Size: As indicated **OR as directed**.
4. PVC Foot Grille: 1/8-by-1-1/2-by-1-inch (3-by-38-by-25-mm) ribbed top, PVC tread bars joined with 3/8-inch (10-mm) stainless-steel rods with 1-1/16-inch- (27-mm-) long nylon spacers at 12 inches (300 mm) o.c. Provide PVC frame with nylon anchors.
   a. Colors: As selected from manufacturer's full range.
   b. Grille Size: As indicated **OR as directed**.
5. Lockdown: Manufacturer's standard **OR** Hidden **OR** In view, **as directed**.

C. Frames
1. Provide manufacturer's standard frames of size and style for grille type, for permanent recessed installation in subfloor, complete with installation anchorages and accessories. Unless otherwise indicated, fabricate frame of same material and finish as grilles.

D. Support System
1. Level Bed Applications: Provide manufacturer's standard, vinyl cushion support system.
2. Drainage Pit Applications: Provide manufacturer's special deep-pit frame and support extrusion system with intermediate support beams, sized and spaced as recommended by manufacturer for indicated spans and equipped with vinyl support cushions.

E. Drain Pans
1. Provide manufacturer's standard, 0.060-inch- (1.52-mm-) thick, **as directed**, metallic-coated steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet drain pan with NPS 2 (DN 50) drain outlet for each floor grille unit. Coat bottom of pan with protective coating recommended by manufacturer.

F. Fabrication

1. Shop fabricate foot grilles to greatest extent possible in sizes as indicated. Unless otherwise indicated, provide each grille as a single unit; do not exceed manufacturer's recommended maximum sizes for units that are removed for maintenance and cleaning. Where joints in grilles are necessary, space symmetrically and away from normal traffic lanes.
2. Fabricate frame members in single lengths or, where frame dimensions exceed maximum available lengths, provide minimum number of pieces possible, with hairline joints equally spaced and pieces spliced together by straight connecting pins.

G. Finishes, General
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

H. Aluminum Finishes
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Mill Finish: AA-M10 (Mechanical Finish: as fabricated); grind and buff as required to remove scratches, welding, or abrasions produced in fabrication process.
3. Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
4. Class I, Clear Anodic Finish: AA-M12C22A41 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
5. Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).
6. Class I, Color Anodic Finish: AA-M12C22A42/A44 (Mechanical Finish: nonspecular as fabricated; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

I. Stainless-Steel Finishes
1. Mill finish.
2. Directional Satin Finish: No. 4.
   a. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.

J. Copper-Alloy (Bronze) Finishes
1. Finish designations for copper alloys comply with the system established for designating copper-alloy finish systems defined in NAAMM's "Metal Finishes Manual for Architectural and Metal Products."
   a. Remove tool and die marks and stretch lines or blend into finish.
   b. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.
2. Mechanical Finish Designation: M11, specular, as fabricated **OR** M32, directionally textured, medium satin, **as directed**.

1.3 EXECUTION

A. Installation
1. Install recessed foot grilles and frames and drain pans to comply with manufacturer's written instructions at locations indicated and with top of foot grilles and frames in relationship to one another and to adjoining finished flooring as recommended by manufacturer. Set foot-grille tops

at height for most effective cleaning action. Coordinate top of foot-grille surfaces with doors that swing across grilles to provide clearance under door.

B. Protection

1. After completing frame installations, provide temporary filler of plywood or fiberboard in foot-grille recesses and cover frames with plywood protective flooring. Maintain protection until construction traffic has ended and Project is near Substantial Completion.

END OF SECTION 12480

SECTION 12610 - FIXED AUDIENCE SEATING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for fixed audience seating. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes fixed audience seating with the following:
   a. Standard, Beam, and Pedestal mounting.
   b. Upholstered chairs, Molded-plastic chairs and Molded-plastic chairs with upholstered inserts.
   c. Self-rising seat mechanism.
   d. Power and data service to individual seats.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
   a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that wood and wood-based materials comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
      1) Include statement indicating costs for each certified wood product.
   b. Product Data for Credit EQ 4.4: For each composite wood product, documentation indicating that product contains no urea formaldehyde.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Seating Layout: Show seating layout, aisle widths, row-lettering and chair-numbering scheme, chair widths, and chair spacing in each row.
   b. Accessories: Show accessories, including locations of left- and right-hand tablet arms, electrical devices, accessibility provisions, and attachments to other work.
   c. Wiring Diagrams: For power, signal, and control wiring.
4. Samples: For each seating component and for each color and texture required.
5. Product Certificates: For each type of flame-retardant treatment of fabric, from manufacturer.
6. Maintenance Data.
7. Warranty: Sample of special warranty.

D. Quality Assurance
1. Source Limitations: Obtain fabric of a single dye lot for each color and pattern of fabric required.
2. Forest Certification: Fabricate products with wood components produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
3. Fire-Test-Response Characteristics of Upholstered Chairs:
   a. Fabric: Class 1 according to DOC CS 191 and 16 CFR 1610.61, tested according to California Technical Bulletin 117.
   b. Padding: Comply with California Technical Bulletin 117.
   c. Full-Scale Fire Test: Comply with California Technical Bulletin 133.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Preinstallation Conference: Conduct conference at Project site.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fixed audience seating that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Structural failures including standards, beams, and pedestals.
      2) Faulty operation of self-rising seat mechanism.
      3) Faulty operation of electrical components.
      4) Wear and deterioration of fabric and stitching beyond normal use.
      5) Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
   b. Warranty Periods: As follows, from date of Substantial Completion.
      1) Structural: Five years **OR** 10 years **OR** Lifetime, **as directed**.
      2) Operating Mechanisms: Three years **OR** Five years **OR** Lifetime, **as directed**.
      3) Electrical Components: Three **OR** Five, **as directed**, years.
      4) Plastic, Wood, and Paint Components: Two **OR** Three **OR** Five, **as directed**, years.

1.2 PRODUCTS

A. Materials And Finishes
1. Steel: ASTM A 36/A 36M plates, shapes, and bars; ASTM A 513 mechanical tubing; ASTM A 1008/A 1008M cold-rolled sheet; and ASTM A 1011 hot-rolled sheet and strip.
2. Cast Iron: ASTM A 48/A 48M, Class 25 (Class 175), gray iron castings free of blow holes and hot checks with parting lines ground smooth.
3. Cast Aluminum: ASTM B 85 aluminum-alloy die castings.
4. Metal Finish: Finish exposed metal parts with manufacturer's standard polyurethane **OR** baked-on **OR** minimum 1.5-mil- (0.04-mm-) thick, polyester baked-on powder **OR** minimum 1.5-mil- (0.04-mm-) thick, epoxy baked-on powder, **as directed**, coating.
   a. Color: As selected from manufacturer's full range.
5. Medium-Density Fiberboard: ANSI A208.2, Grade MD, made with binder containing no urea formaldehyde.
6. Concealed Plywood: HPVA HP-1 hardwood plywood, made with adhesive containing no urea formaldehyde, or DOC PS 1 softwood plywood, as standard with manufacturer.
7. Exposed Plywood: HPVA HP-1, Face Grade A, hardwood veneer core with color-matched hardwood-veneer faces, made with adhesive containing no urea formaldehyde.
8. Hardwood Lumber and Veneer Faces: American black walnut **OR** Red oak **OR** Teak **OR** Birch **OR** Cherry **OR** Maple, **as directed**, selected to be free of visible defects.
   a. Stain and Finish: As selected from manufacturer's full range.
9. Plastic Laminate: NEMA LD 3, Grade VGS for vertical surfaces and Grade HGS for horizontal surfaces.
   a. Color and Pattern: As selected from manufacturer's full range.
10. Fabric: Manufacturer's standard 100 percent nylon **OR** 100 percent polyolefin, **as directed**, with flame-retardant treatment.
    a. Weight: 12 oz./linear yd. (0.37 kg/linear m) **OR** 16 oz./linear yd. (0.50 kg/linear m) **OR** 18 oz./linear yd. (0.56 kg/linear m) **OR** 20 oz./linear yd. (0.62 kg/linear m), **as directed**.
    b. Color and Pattern: As selected from manufacturer's full range.
11. Upholstery Padding: Flexible, cellular, molded or slab polyurethane foam.
12. Molded Plastic: High-density polyethylene or polypropylene, blow or injection molded, with smooth or textured surface that is mar and dent resistant.
    a. Provide with UV inhibitors to retard fading where exposed to sunlight.
    b. Color and Texture: As selected from manufacturer's full range.

B. Fixed Audience Seating
1. Chair Mounting Standards: Floor **OR** Riser, **as directed**, attached of the following material:

a. Steel: One-piece heavy-tube or reinforced sheet with welded mounting plate and welded connections for seat pivots, backs, armrests, and end panels.
b. Cast Iron **OR** Aluminum, **as directed**: One-piece castings with integral mounting points and attachment anchoring points for seat pivots, backs, and armrests.
c. Molded Plastic: One-piece, solid injection-molded plastic with integral reinforcing ribs and attachment anchoring points for seat pivots, backs, and armrests.

2. Chair Mounting Beam: Steel horizontal beam mounted on floor-attached **OR** riser-attached, **as directed**, steel support pedestals spaced at intervals of 2 to 2-1/2 chair widths.
3. Chair Mounting Pedestal: Floor-attached pedestal, manufacturer's standard jury base with swivel **OR** diffuser pedestal, **as directed**.
4. End Panels:
   a. Material: Steel **OR** Cast iron with design **OR** Cast aluminum with design **OR** Plastic laminate **OR** Hardwood-veneer plywood **OR** Solid hardwood **OR** Fabric upholstered **OR** Molded plastic, **as directed**.
      1) Cast-Metal Design: As selected from manufacturer's full range.
   b. Decorative Insert: Plastic laminate **OR** Hardwood-veneer plywood **OR** Solid hardwood **OR** Fabric upholstered **OR** Molded plastic **OR** Customized medallion, **as directed**.
   c. Style: Rectangular **OR** Oval **OR** Teardrop **OR** Tapered **OR** Panel to floor (pew), **as directed**, with square **OR** rounded, **as directed**, corners.
5. Fabric Upholstered Chairs:
   a. Backs:
      1) Padding Thickness: 1-1/4 inches (32 mm) **OR** 2 inches (51 mm) **OR** 3 inches (76 mm), **as directed**.
      2) Rear Panel: Steel **OR** Molded plastic **OR** Fabric upholstered with 1/4-inch (6-mm) padding **OR** Plastic laminate **OR** Hardwood-veneer plywood, **as directed**.
      3) Top Corners: Square **OR** Rounded, **as directed**.
      4) Upholstery Options: Tufting **OR** Decorative stitching, **as directed**.
   b. Seats: Two part **OR** One part with slip-on upholstered padding **OR** One part, fully upholstered, **as directed**, and as follows:
      1) Padding Thickness: Minimum 1-1/2 inches (38 mm) **OR** 3 inches (76 mm) **OR** 4 inches (102 mm), **as directed**, at front and rear edge.
      2) Seat Underside: Steel sheet seat pan **OR** Perforated steel sheet seat pan with acoustical insulation **OR** Hardwood-veneer-faced, formed plywood shell **OR** Molded-plastic shell **OR** Fabric upholstered with padding, **as directed**.
6. Plastic Chairs: One-piece **OR** Two-piece, **as directed**, molded plastic and as follows:
   a. Back: Smooth surface **OR** Textured surface **OR** Formed slats **OR** Smooth surface with upholstered inserts, **as directed**, with square **OR** rounded, **as directed**, top corners.
   b. Seat: Smooth surface **OR** Textured surface **OR** With simulated slats **OR** Smooth surface with upholstered inserts, **as directed**.
   c. Upholstered Inserts: Padding and fabric covering over 1/8-inch (3-mm) plywood or fiberboard backing board, recessed 3/16 inch (5 mm) into seat and back, centered, and attached with hidden, vandal-resistant fasteners.
7. Chair Width: Vary chair widths to accommodate sightlines and row lengths **OR** Single width chair in each row, **as directed**, with minimum chair width of 18 inches (457 mm) **OR** 19 inches (483 mm) **OR** 20 inches (508 mm) **OR** 22 inches (559 mm) **OR** 23 inches (584 mm) **OR** 24 inches (610 mm), **as directed**, from center to center of armrests.
8. Back Height: Standard-style **OR** High-style **OR** Planetarium-style, **as directed**, backs, 31 inches (787 mm) **OR** 32-1/2 inches (826 mm) **OR** 35 inches (889 mm) **OR** 38 inches (965 mm) **OR** 40 inches (1016 mm) **OR** 44 inches (1117 mm), **as directed**, high.
9. Back Pitch: Fixed **OR** Variable, hinged (rocker), **as directed**.
10. Chair Seat Hinges: Self-lubricating, compensating type with noiseless self-rising seat mechanism passing ASTM F 851 and with positive internal stops cushioned with rubber or neoprene.
11. Chair Back Hinges: Self-lubricating type with noiseless mechanism that raises back to vertical position when chair is unoccupied.
12. Self-Rising Seat Mechanism: Spring-actuated, three-quarter fold **OR** Spring-actuated, full fold **OR** Gravity-actuated, full fold, **as directed**.

13. Armrests: Plastic **OR** Hardwood **OR** Upholstered **OR** Plastic laminate on medium-density fiberboard **OR** Integral scrolled cast iron, **as directed**, with rounded edges, concealed mounting, and integral cup holder, **as directed**.
14. Aisle Lighting Fixtures: Manufacturer's standard round **OR** rectangular louvered **OR** concealed in armrest, **as directed**, fixtures.
    a. Bulb: LED **OR** Incandescent, **as directed**.
    b. Power: 24 **OR** 120, **as directed**, V.
    c. For low-voltage lighting, provide manufacturer's voltage-reduction device housed in safety enclosure equipped with fuses, terminal blocks, and safety disconnect.
15. Power and Data Service Package: Manufacturer's standard service **OR** Service, **as directed**, to individual seats including terminal devices and wiring with 18 inches (457 mm) of extra length and as follows.
    a. Power Receptacles: 120 V with wiring and receptacle as specified in Division 15.
    b. Data Ports: Data port terminal with wiring and receptacle jack as specified in Division 15.
    c. Location: Manufacturer's standard location **OR** On raceway beneath the seating **OR** In the armrest **OR** Beneath the armrest on front or side of the standard **OR** In back panel of seat in front, **as directed**.
16. Row-Letter and Chair-Number and Donor Plates: Manufacturer's standard.
    a. Material: Aluminum **OR** Bronze **OR** Stainless steel, **as directed**, with black embossed characters.
    b. Attachment: Manufacturer's standard method **OR** Adhesive **OR** Minimum of two mechanical fasteners, **as directed**.
17. Tablet Arms: Manufacturer's standard-size **OR** Manufacturer's oversize, **as directed**, fixed **OR** foldaway, **as directed**, tablet arm with plastic-laminate writing surface over medium-density fiberboard or plywood core and with rounded, matching PVC edges.
    a. Mounting: Right-hand mounted unless otherwise indicated.
    b. Fold-Away Mechanism: Cast-iron or steel hinge and swivel mechanism that gives positive support in open position and semiautomatic return to stored position below arm block and parallel to chair.
18. Accessible Seating:
    a. Provide removable **OR** rollaway **OR** swing-away, **as directed**, chairs where wheelchair spaces are indicated.
    b. Provide chairs without **OR** with retractable **OR** with foldup, **as directed**, arm on aisle side in locations indicated, but not less than 5 percent of aisle seats. Identify these seats with a sign or marker.

C. Fabrication
1. Floor Attachments: Fabricate to conform to floor slope, if any, so that standards and pedestals are plumb and chairs are maintained at same angular relationship to vertical throughout Project.
2. For beam-mounted chairs in curved patterns, curve the beam to the various radii required for the rows.
3. Upholstery: Fabricate fabric-covered cushions with molded padding beneath fabric and with fabric covering free of welts, creases, stretch lines, and wrinkles. For each upholstered component, install pile and pattern run in a consistent direction.
4. Upholstered Chairs: Fabricate as follows:
    a. Two-Part Upholstered Back: In length required to protect seat in raised position, with padded cushion glued to a curved steel, plywood, or molded-plastic support panel covered with easily replaceable fabric, and with curved rear shell that fully encloses upholstery edges.
    b. Two-Part Seats: Upper part, an upholstered cushion with molded padding over no fewer than five serpentine springs attached to reinforced steel frame, with weight-distributing and abrasion-resistant sheeting separating padding from springs, and removable for reupholstering without removing seat from chair. Lower part, steel pan reinforced at stress points and completely enclosing hinges and self-rising mechanism.
    OR

Two-Part Seats: Upper part, an upholstered cushion with formed padding over a five-ply plywood panel with fabric cover conforming to shape of cushion to conceal inner seat structure and hinge mechanism. Lower part, molded-plastic shell.

c. One-Part Seats: Double-wall plastic shells fitted with a padded upholstered cushion and covered with easily replaceable fabric **OR** padded and fully upholstered, **as directed**.

5. Two-Piece, Molded-Plastic Chairs: Fabricate contoured seat and back separately with double-wall, blow-molded plastic. Fabricate back in length required to protect seat in raised position. Reinforce plastic with steel plates at attachment points.
6. One-Piece, Molded-Plastic Chairs: Provide contoured plastic shell with smoothly rolled edges and reinforcing ribs on underside of shell. Fabricate for attachment of chair to support with self-threading, corrosion-resistant screws.

1.3 EXECUTION

A. Installation
1. Install seating in locations indicated and fastened securely to substrates according to manufacturer's written installation instructions.
   a. Use installation methods and fasteners that produce fixed audience seating assemblies with individual chairs capable of supporting an evenly distributed 600-lb (272-kg) static load without failure or other conditions that might impair the chair's usefulness.
   b. Install standards and pedestals plumb.
2. Install seating with chair end standards aligned from first to last row and with backs and seats varied in width **OR** spacing **OR** width and spacing, **as directed**, to optimize sightlines.
3. Install riser-mounted attachments to maintain uniform chair heights above floor.
4. Install chairs in curved rows at a smooth radius.
5. Install seating so moving components operate smoothly and quietly.
6. Install wiring conductors and cables concealed in components of seating and accessible for servicing.

B. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
   b. Tests for Power Receptacles: As specified in Division 15.
   c. Tests for Data Ports: As specified in Division 15.
2. Prepare test and inspection reports.

C. Adjusting
1. Adjust chair backs so that they are aligned with each other in straight **OR** uniformly curved, **as directed**, rows.
2. Adjust self-rising seat mechanisms so seats in each row are aligned when in upright position.
3. Verify that all components and devices are operating properly.
4. Verify that seating returns to correct at-rest position.
5. Repair minor abrasions and imperfections in finishes with coating that matches factory-applied finish.
6. Replace upholstery fabric damaged during installation.

END OF SECTION 12610

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Task	Specification	Specification Description
12610	01352	No Specification Required

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SECTION 12661 - TELESCOPING STANDS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for telescoping stands. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Wall-attached and Recessed telescoping stands.
b. Floor-attached and Reverse-fold, freestanding telescoping stands.
c. Portable telescoping stands.

C. Submittals
1. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for telescoping stands.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
a. Include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
b. Include wiring diagrams for electrically operated units.
c. Indicate field measurements on Shop Drawings.
3. Samples: For each exposed finish.
4. LEED Submittal:
a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that wood and wood-based materials comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
1) Include statement indicating costs for each certified wood product.
5. Qualification Data: For Installer.
6. Operation and maintenance data.

D. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Manufacturer's Engineering Responsibility: Preparation of data for telescoping stands, including Shop Drawings, and comprehensive engineering analysis by a qualified professional engineer.
3. Safety Standard: Provide telescoping stands that comply with requirements in ICC 300 **OR** NFPA 102, **as directed**.
4. Welding: Qualify procedures and personnel according to AWS D1.1 "Structural Welding Code - Steel" and AWS D1.3 "Structural Welding Code - Sheet Steel."
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
6. Accessibility Requirements: Provide telescoping stands that comply with requirements in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)".
7. Fire-Test-Response Characteristics of Upholstered Chairs:
a. Padding: Comply with California Technical Bulletin 117.
8. Forest Certification: Fabricate products with wood components produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
9. Preinstallation Conference: Conduct conference at Project site.

1.2 PRODUCTS

A. Materials
1. Wood:
a. Lumber: Kiln-dried, surfaced four sides; southern pine complying with SPIB's "Standard Grading Rules for Southern Pine Lumber" for C&Btr Finish (C and better) **OR** B&B Finish (B and better), **as directed**, grade-of-finish requirements.
b. Plywood: APA grade trademarked, DOC PS 1.
2. Steel:
a. Structural Steel Shapes, Plates, and Bars: ASTM A 36/A 36M.
b. Galvanized Steel Sheet: ASTM A 653/A 653M, G90 (Z275) coating designation.
c. Uncoated Steel Sheet: ASTM A 1008/A 1008M, Designation CS (cold-rolled commercial steel), or ASTM A 1011/A 1011M, Designation CS (hot-rolled commercial steel).
d. Tubing: ASTM A 500, cold formed; ASTM A 501, hot formed; or ASTM A 513, mechanical.
3. Extruded Aluminum: ASTM B 221 (ASTM B 221M), alloy as standard for manufacturer.
4. Polyethylene Plastic: High-density polyethylene; molded, color-pigmented, textured, impact-resistant, structural formulation.

B. Telescoping Stands
1. Description: Operable systems of multiple-tiered seating on interconnected folding platforms that close, without being dismantled, into a nested stack for storing or moving. Stand units permit opening and closing of adjacent rows, allow individual and collective rows to be locked open for use, and close with vertical faces of upper skirts on the same vertical plane.
2. Wall-Attached Telescoping Stands: Rear of understructure permanently attaches to wall construction.
a. Operation: Manual **OR** Automatic, friction-type integral power unit **OR** Automatic, nonfriction-type integral power unit **OR** Automatic, power assisted by portable, manually guided, electrically powered unit, **as directed**.
1) Limit Switches: Automatically stop integral power system when telescoping stands reach fully opened or closed positions.
2) Motion Monitor: Flashing light with self-contained warning horn, rated at 85 decibels (dB) at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
3) Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.
3. Recessed Telescoping Stands: Rear of understructure permanently attaches to construction so that closed stands are recessed in opening indicated on Drawings **OR as directed**.
a. Operation: Manual **OR** Automatic, friction-type integral power unit **OR** Automatic, nonfriction-type integral power unit **OR** Automatic, power assisted by portable, manually guided, electrically powered unit, **as directed**.
1) Limit Switches: Automatically stop integral power system when telescoping stands reach fully opened or closed positions.
2) Motion Monitor: Flashing light with self-contained warning horn, rated at 85 decibels (dB) at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
3) Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.
4. Floor-Attached, Freestanding Telescoping Stands: Rear of understructure permanently attaches to floor construction, and stand unit closes by moving the front to the rear for storage.
a. Operation: Manual **OR** Automatic, friction-type integral power unit **OR** Automatic, nonfriction-type integral power unit **OR** Automatic, power assisted by portable, manually guided, electrically powered unit, **as directed**.
1) Limit Switches: Automatically stop integral power system when telescoping stands reach fully opened or closed positions.

2) Motion Monitor: Flashing light with self-contained warning horn, rated at 85 decibels (dB) at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
3) Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.

5. Reverse-Fold, Freestanding Telescoping Stands: Front row permanently anchors to floor, and stand unit closes by moving the rear forward for storage. Front-row anchorage allows stands to move 36 inches (914.4 mm) or more, as standard with manufacturer, for additional aisle space when stands are open.
   a. Operation: Manual **OR** Automatic, friction-type integral power unit **OR** Automatic, nonfriction-type integral power unit **OR** Automatic, power assisted by portable, manually guided, electrically powered unit, **as directed**.
      1) Limit Switches: Automatically stop integral power system when telescoping stands reach fully opened or closed positions.
      2) Motion Monitor: Flashing light with self-contained warning horn, rated at 85 decibels (dB) at 10 feet (3 m), mounted under telescoping seating for audio and visual warning during integral power operation.
      3) Transformer: As required to coordinate current characteristics of motor and control station with building electrical system.
6. Portable Telescoping Stands: Manually operated stands that can be relocated using lift trucks to produce different seating arrangements.
   a. Transport System: Self-contained hydraulic system, integral to stands **OR** Self-contained air-pallet system, integral to stands **OR** Portable hydraulic dollies **OR** Portable air-pallet dollies, **as directed**, that move stands without marring or damaging floor over which stands move.
      1) Quantity: Two dollies.
7. Row Spacing: As indicated on Drawings **OR as directed**.
8. Row Rise: As indicated on Drawings **OR as directed**.
9. Elevated Front Row: In height indicated on Drawings **OR as directed**.
10. Bench Seats and Skirts:
    a. Material: Lumber with transparent finish **OR** Molded polyethylene plastic with contour seat surface **OR** Steel sheet with vinyl-clad finish, **as directed**.
       1) Colors: As selected from manufacturer's standard.
    b. Bench Height: Not less than 16 inches (406.4 mm) or more than 18 inches (457.2 mm).
    c. Bench Depth: 10 inches (254 mm) **OR** 12 inches (304.8 mm), **as directed**.
11. Chairs: Rotating from upright, locked position to folded-down position that allows supporting platform to telescope for storage. In upright position, seats fold up to allow passage of persons within row.
    a. Operation: Manual **OR** Spring assisted, manual fold up. Automatic release from upright position, except for first row, and automatic fold down to stored position **OR** Automatic, **as directed**.
    b. Chair Width: As indicated on Drawings **OR as directed**.
    c. Seat Height: Not less than 17 inches (431.8 mm) or more than 18 inches (457.2 mm).
    d. Seats: Polyethylene plastic **OR** Polyethylene plastic with padded upholstery insert **OR** Fully upholstered spring seat, **as directed**.
       1) Color: As selected from manufacturer's full range.
    e. Backs: Polyethylene plastic **OR** Polyethylene plastic with padded upholstery insert **OR** Fully upholstered, **as directed**.
       1) Color: As selected from manufacturer's full range.
    f. Armrests: Polyethylene plastic.
       1) Color: As selected from manufacturer's full range.
12. Wheelchair-Accessible Seating: Locate cutouts **OR** retractable truncated benches **OR** removable modular chairs, **as directed**, to provide wheelchair-accessible seating at locations indicated on Drawings.
    a. Equip tiers adjacent to wheelchair-accessible seating with front rails as required by referenced safety standard.

b. Equip cutouts with full-width front closure panels that match decking construction and finish and that extend from underside of tiers adjacent to cutouts to 1-1/2 inches (38.1 mm) from finished floor.

13. Deck: Plywood.
    a. Finish: Polyethylene textured overlay bonded to substrate with exterior glue **OR** Transparent finish **OR** Manufacturer's standard finish, **as directed**.
    b. Color: As selected from manufacturer's standard colors.
14. Risers: Steel sheet with manufacturer's standard rust-inhibiting coating or hot-dip galvanized finish.
15. Rails: Structural steel, finished with manufacturer's standard powder coat system.
    a. Color: Black.
16. Understructure: Structural steel.
    a. Finish: Manufacturer's standard **OR** Water-based acrylic **OR** Alkyd-enamel two-coat system, **OR** Epoxy-resin-based textured powder coat system, **as directed**, rust-inhibiting finish.
    b. Color: Manufacturer's standard.
17. Support Column Wheels: Nonmarring, soft, rubber-face wheel assembly under each support column.
    a. Include wheels of size, number, and design required to support stands and operate smoothly without damaging the flooring surface, but not less than four per column or less than 3-1/2 inches (88.9 mm) in diameter and 1 inch (25.4 mm) wide.
18. Aisle Closures: Manufacturer's standard that produce flush vertical face at aisles when system is stored.
19. Fasteners: Vibration proof, in manufacturer's standard size and material.
20. Accessories:
    a. Slip-resistant, abrasive tread nosings **OR** surfaces, **as directed**, at vertical aisles.
    b. Intermediate aisle steps, fully enclosed, at each vertical aisle.
    c. Transitional top step, fully enclosed, at each vertical aisle where last row of telescoping stands is adjacent to a cross aisle.
    d. Removable front steps, fully enclosed, at each vertical aisle, that engage with front row to prevent accidental separation or movement and are equipped with a minimum of four skid-resistant feet.
    e. Portable access-stair units equipped with handrails, with not less than four full-swiveling, nonmarring wheels and a locking mechanism to prevent movement during use.
    f. Removable **OR** Folding, nonremovable, **as directed**, mid-aisle handrails located at centerline of each vertical aisle with seating on both sides.
    g. End rails (guards) that are telescoping and self-storing **OR** removable, **as directed**.
    h. Back rails (guards) along rear of units where required by referenced safety standard.
    i. Front rails (guards) along front of units where required by referenced safety standard.
    j. Removable, programming-support front rails to allow seating in upper rows while lower rows remain in the stored position.
    k. Rear fillers including supports for closing openings between top row and rear wall of adjoining construction.
    l. Gap fillers for closing openings between stand units or between stand units and adjoining construction.
    m. End panels covering exposed ends of stands in stored position.
    n. Back panels covering rear of freestanding units. Panels extend full height and width of unit.
    o. Removable scorer's table that attaches to mounting sockets installed in telescoping stand unit.
    p. Folding backrests permanently attached to bench units.
        1) Material: Lumber with transparent finish **OR** Molded polyethylene plastic with contour support surface in color matching seat, **as directed**.
    q. Row letters at each row end.
    r. Seat numbers at 18 inches (457 mm) o.c. on benches and on each chair.

s. Removable spanner seats, designed to span area between adjacent stand units, in locations indicated on Drawings **OR as directed**.

C. Fabrication
1. Fabricate understructure from structural steel members in size, spacing, and form required to support design loads specified in referenced safety standard.
2. Weld understructure to comply with applicable AWS standards.
3. Round corners and edges of components and exposed fasteners to reduce snagging and pinching hazards.
4. Form exposed sheet metal with flat, flush surfaces, level and true in line, and without cracking and grain separation.
5. Seating Supports: Fabricate supports to withstand, without damage to components, the forces imposed by use of stands without failure or other conditions that might impair the usefulness of seating units.
   a. Cantilever bench seat supports to produce toe space uninterrupted by vertical bracing.

1.3 EXECUTION

A. Installation
1. Install telescoping stands to comply with referenced safety standard and manufacturer's written instructions.

B. Adjusting And Cleaning
1. On completion of installation, lubricate, test, and adjust each telescoping stand unit so that it operates according to manufacturer's written operating instructions.
2. Clean installed telescoping stands on exposed and semiexposed surfaces. Touch up shop-applied finishes or replace components as required to restore damaged or soiled areas.

END OF SECTION 12661

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SECTION 13091 - RADIATION PROTECTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for radiation protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Lead sheet, strip, and plate.
b. Lead bricks.
c. Lead glass.
d. Lead glazing plastic.
e. Lead-lined building materials and products including the following:
1) Concrete masonry units.
2) Gypsum lath.
3) Gypsum base for gypsum veneer plaster and board.
4) Steel hollow-metal doors and door frames.
5) Wood doors.
6) Observation-window frames.
7) Modular shielding partitions.
8) Film transfer cabinets.
9) Neutron-shielding doors, frames, and hardware.
f. Informational signs.

C. Definitions
1. Lead Equivalence: The thickness of lead that provides the same attenuation (reduction of radiation passing through) as the material in question under the specified conditions.
a. Lead equivalence specified for materials used in diagnostic x-ray rooms is as measured at 100 kV unless otherwise indicated.

D. Performance Requirements
1. Provide materials and workmanship, including joints and fasteners, that maintain continuity of radiation protection at all points and in all directions equivalent to materials specified in thicknesses and locations indicated.
a. Materials, thicknesses, and configurations indicated are based on radiation protection design prepared by Owner's radiation health physicist. This design is available to Contractor on request.
2. Lead-Lined Assemblies: Unless otherwise indicated, provide lead thickness in doors, door frames, window frames, penetration shielding, joint strips, film transfer cabinets, and other items located in lead-lined assemblies not less than that indicated for assemblies in which they are installed.
3. Lead Glazing: Unless otherwise indicated, provide lead equivalence not less than that indicated for assembly in which glazing is installed.

E. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Certificates for Credit MR 7: Chain-of-custody certificates certifying that wood veneer on doors complies with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.

1) Include statement indicating costs for certified wood veneer doors.

3. Shop Drawings: Show layout of radiation-protected areas. Indicate lead thickness or lead equivalence of components. Show components and installation conditions not fully dimensioned or detailed in product data.
   a. Show ducts, pipes, conduit, and other objects that penetrate radiation protection; include details of penetrations.
   b. Show details of neutron-shielding doors and frames, including anchorage to and coordination with other work. Show locations of electrical conduit and boxes for connecting door operators, door operator switches, and door interlock switches.
      1) Wiring Diagrams: For power, signal, and control wiring.
4. Samples: For each exposed product and for each color and texture specified.
5. Field quality-control reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

F. Quality Assurance
1. Forest Certification: Provide wood veneers for doors produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
2. Fire-Rated and Smoke-Control, **as applicable**, Door and Frame Assemblies: Comply with Division 08 Section(s) "Steel Doors And Frames" OR "Flush Wood Doors", **as applicable**.
3. Glazing: Comply with requirements in Division 08 Section "Glazing".
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Preinstallation Conference: Conduct conference at Project site.

G. Delivery, Storage, And Handling
1. Lead-Lined Gypsum Panels: Neatly stack panels flat to prevent deformation.
2. Lead-Lined Steel Doors and Frames: Comply with requirements in Division 08 Section "Steel Doors And Frames" for delivery, storage, and handling.
   OR
   Lead-Lined Steel Doors and Frames: Deliver doors and frames cardboard wrapped or crated to provide protection during delivery and storage. Inspect for damage on delivery. Minor damage may be repaired provided the refinished repair matches new work and is approved by the Owner; otherwise, remove and replace damaged items as directed.
3. Lead-Lined Wood Doors: Comply with requirements in Division 08 Section "Flush Wood Doors" for delivery, storage, and handling.
   OR
   Lead-Lined Wood Doors: Comply with manufacturer's written instructions and requirements in WDMA I.S.1-A.
4. Package doors individually in plastic bags or cardboard cartons **OR** cardboard cartons and wrap bundles of doors in plastic sheeting, **as directed**.
5. Mark each door on bottom **OR** top and bottom, **as directed**, rail with opening number used on Shop Drawings.

H. Warranty
1. Comply with requirements in Division 08 Section "Flush Wood Doors".

1.2 PRODUCTS

A. Materials
1. Lead Sheet, Strip, and Plate: ASTM B 749, alloy UNS No. L51121 (chemical-copper lead).
2. Lead Bricks: Interlocking cast- or extruded-lead bricks made from pig lead, complying with ASTM B 29 with 1/2 percent antimony added, with tongues and grooves on adjoining edges.

3. Borated Polyethylene: Manufactured specifically for neutron shielding and containing not less than 5 percent boron.
4. Lead Glass: Lead-barium, polished float glass containing not less than 60 percent heavy metal oxides, including not less than 48 percent lead oxide by weight.
   a. Safety Glass: Fully tempered **OR** Laminated, **as directed**, float glass.
      1) Outer Lite: Clear float glass; thickness as indicated **OR as directed**.
      2) Interlayer: Clear polyvinyl butyral or cured resin of manufacturer's standard thickness indicated with a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after laminating glass lites and installation.
      3) Inner Lite: Lead-barium, polished float glass; thickness as indicated **OR as directed**.
5. Lead Glazing Plastic: Transparent acrylic sheet impregnated with an organolead compound and containing 30 percent lead by weight.
6. Lead-Lined Concrete Masonry Units: Fabricated from two solid concrete units, complying with ASTM C 90 or ASTM C 129, separated vertically by a single sheet of lead permanently bonded or anchored between the two halves. Size lead sheets to provide a 1-inch (25-mm) overlap with adjacent units or provide supplemental lead to ensure uninterrupted protection.
   a. Provide special shapes as needed to maintain bond without cutting units.
   b. Provide lead wool for filling voids or joints.
7. Masonry Mortar: Comply with Division 04 Section "Unit Masonry Assemblies".
   OR
   Masonry Mortar: Comply with ASTM C 270, Type N, Proportion Specification.
   a. Limit cementitious materials to portland cement and hydrated lime, **as directed**.
8. Grout: ASTM C 476, with a slump of 8 to 11 inches (200 to 280 mm) as measured according to ASTM C 143/C 143M.
   a. For grouting frames of neutron-shielding doors, use coarse grout made from aggregate having a density not less than that used for concrete walls in which frames are installed.
9. Lead-Lined Gypsum Lath: 3/8-inch- (9.5-mm-) **OR** 1/2-inch- (12.7-mm-), **as directed**, thick gypsum lath complying with Division 09 Section "Gypsum Plaster" with a single sheet of lead, 1 inch (25 mm) longer and wider than lath, laminated to the back of lath so lead extends 1 inch (25 mm) beyond one side and one end.
   a. For metal or wood furring and framing, provide 5/8-inch- (16-mm-) diameter lead disks or 5/8-by-1-1/4-inch (16-by-32-mm) lead tabs for covering screw heads.
   b. For wood, provide lead-headed nails for fastening lead-lined gypsum lath, accessories, and trim to wood members.
10. Lead-Lined Gypsum Base for Gypsum Veneer Plaster **OR** Board, **as directed**: 1/2-inch- (12.7-mm-) **OR** 5/8-inch- (16-mm-), **as directed**, thick gypsum board complying with Division 09 Section(s) "Gypsum Veneer Plastering" OR "Gypsum Board", **as directed**, of width and length required for support spacing and to prevent cracking during handling, and with a single sheet of lead laminated to the back of the board.
    a. Provide lead sheet lining the full width and length of board **OR** of board and length necessary to extend from floor to 84 inches (2133 mm) above floor **OR** of board and height as indicated on Drawings, **as directed**.
    b. Provide 3-inch- (75-mm-) wide lead strips for wrapping metal stud flanges.
    c. Provide 2-inch- (50-mm-) wide lead strips for backing joints.
    d. Provide 5/16-inch (8-mm) **OR** 5/8-inch (16-mm), **as directed**, lead disks for covering screw heads.
    e. Provide lead-headed nails for fastening gypsum board, accessories, and trim to wood members.
11. Accessories and Fasteners: Provide manufacturer's standard fasteners and accessories as required for installation, maintaining same lead equivalence as rest of system.
12. Asphalt Coating: Cold-applied asphalt emulsion complying with ASTM D 1187.
13. Asphalt Felt: ASTM D 226.

B. Lead-Lined Steel Hollow-Metal Doors

1. General: Steel doors complying with ANSI/NAAMM-HMMA 861, except with a single continuous sheet of lead of thickness not less than that required for partition in which door is installed **OR** as indicated on Drawings, **as directed**, and extending from top to bottom and edge to edge, installed either between back-to-back stiffeners or between stiffeners and stop face of door.
   a. Line inverted channels at top and bottom of doors with lead sheet of same thickness used in door and close with filler channels to provide flush top and bottom edges.
   b. Shield cutouts for locksets with lead sheet of same thickness used in door. Lap lining of cutouts with door lining 1 inch (25 mm).
   c. Prepare doors to receive observation windows **OR** louvers **OR** windows and louvers, **as directed**; cut and trim openings through doors in factory. Provide removable stops for glazed openings.
   d. Provide lead-lined astragals for pairs of doors.
   e. Factory fit doors to suit frame-opening sizes indicated with 1/16-inch (1.5-mm) clearance at heads and jambs and minimum clearance at bottom.
   f. Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating **OR** factory-applied paint, **as directed**.
      1) Color and Gloss: As selected from manufacturer's full range.
2. Lead Door Louvers: Provide louvers with 20 **OR** 30, **as directed**, percent free area, of sizes and types indicated. Fabricate from formed-lead sheet or lead extrusions of not less than lead thickness required for door in which louver is installed. Fabricate louvers to be lightproof with fixed maze-type blades that maintain required lead equivalence at all points and in all directions. Factory fit and assemble louvers in doors before shipping to Project site.

C. Lead-Lined Steel Hollow-Metal Door Frames
1. General: Steel door frames complying with ANSI/NAAMM-HMMA 861, except 0.0667 inch (1.7 mm) thick, and lined with lead sheet of thickness not less than that required for doors and walls where frames are used.
   a. Provide additional reinforcements and internal supports to adequately carry the weight of lead-lined doors. Install reinforcements and supports before installing lead lining.
   b. Form lead sheet to match frame contour, continuous in each jamb and across the head, lapping the stops. Form lead shields around areas prepared to receive hardware. Fabricate lead lining wide enough to maintain an effective lap with lead of adjacent shielding.
   c. Finish: Apply manufacturer's standard primer immediately after cleaning and pretreating **OR** factory-applied paint, **as directed**.
      1) Color and Gloss: As selected from manufacturer's full range.

D. Lead-Lined Wood Doors
1. General: Flush solid-core wood doors with lead lining, thickness not less than that required for partition in which door is installed **OR** as indicated on Drawings, **as directed**.
   a. Door Construction: Veneer face, five **OR** seven, **as directed**, ply, bonded mineral **OR** particleboard **OR** structural composite lumber **OR** glued-wood-stave, **as directed**, core.
      OR
      Door Construction: Plastic-laminate face, three **OR** five, **as directed**, ply, bonded particleboard core.
   b. Lead Lining: One or more continuous sheets of lead extending from top to bottom and edge to edge, constructed either in the core or between the core and faces, at manufacturer's option.
      OR
      Lead Lining: One continuous sheet of lead extending from top to bottom and edge to edge, constructed in the core. Assemble lead lining and core with poured lead fasteners or steel bolts. Space fasteners not more than 1-1/2 inches (38 mm) from door edge and about 8 inches (200 mm) o.c. Countersink bolt heads and cover with lead.
   c. Comply with Division 08 Section "Flush Wood Doors" for grade, faces, veneer matching, fabrication, finishing, and other requirements unless otherwise indicated.

d. Quality Standard: AWI's "Architectural Woodwork Quality Standards Illustrated" **OR** WDMA I.S.1-A, "Architectural Wood Flush Doors" **OR** WI's "Manual of Millwork", **as directed**.

e. Grade: Premium **OR** Custom **OR** Economy, **as directed**.

f. Face Veneer Species and Cut: White oak, rift cut **OR** Red oak, plain sliced **OR** White birch, plain sliced **OR** White birch, rotary cut **OR** Match wood doors that are not lead lined, **as directed**.

1) Veneer Matching: Slip **OR** Book, **as directed**, and running **OR** balance, **as directed**, match.

2) Factory finish with stain and, **as directed**, transparent catalyzed lacquer or conversion varnish.

g. Faces: Any closed-grain hardwood of mill option, for opaque finish.

h. Faces: Plastic laminate complying with NEMA LD 3, Grade HGS.

1) Color, Patterns, and Finishes: As selected from manufacturer's full range.

i. Shield cutouts for locksets with lead sheet of same thickness used in door. Lap lining of cutouts with door lining.

j. Prepare doors to receive observation windows **OR** louvers **OR** observation windows and louvers, **as directed**; cut and trim openings through doors in factory. Provide removable wood stops for glazed openings.

k. Provide lead-lined astragals for pairs of doors.

l. Factory fit doors to suit frame openings indicated with 1/16-inch (1.5-mm) clearance at heads and jambs and minimum clearance at bottom. Factory machine doors for hardware not surface applied.

2. Lead Door Louvers: Provide louvers with 20 **OR** 30, **as directed**, percent free area, of sizes and types indicated. Fabricate from formed-lead sheet or lead extrusions of not less than lead thickness required for door in which louver is installed. Fabricate louvers to be lightproof with fixed maze-type blades that maintain required lead equivalence at all points and in all directions. Factory fit and assemble louvers in doors before shipping to Project site.

E. Lead-Lined Observation-Window Frames

1. General: Fabricate from 0.043-inch- (1.1-mm-) thick, formed-steel sheet or 0.064-inch- (1.6-mm-) thick aluminum extrusions with mitered corners, welded or bolted with concealed fasteners.

a. Line with lead sheet formed to match frame contour, continuous in each jamb and across head and sill, lapping the stops, and fabricated wide enough to maintain an effective lap with lead of adjoining assemblies.

b. Construct so lead lining overlaps glazing material perimeter by at least 3/8 inch (9.5 mm) and provide removable stops.

c. Form sill with an opening for sound transmission. Offset sound passage to make opening lightproof and to maintain required lead equivalence at all points and in all directions.

F. Lead-Lined Modular Shielding Partitions

1. General: Partial-height modular partitions assembled from factory-finished standard components consisting of lead-lined enameled-steel framing members, lead-lined opaque panels, lead glazing plastic vision panels, and hardware necessary for assembly and for securing to other construction. Fabricate opaque panels from honeycomb-core metal panels with polyurethane paint finish.

a. Lead Equivalence for Opaque Panels: 1.5 mm.

b. Lead Equivalence for Framing Members: 1.5 mm.

c. Lead Equivalence for Vision Panels: 1.5 **OR** 1.0 **OR** 0.8 **OR** 0.5, **as directed**, mm.

G. Lead-Lined Film Transfer Cabinets

1. General: Factory-fabricated, double-wall construction, of 0.0428-inch- (1.1-mm-) thick, cold-rolled, stretcher-leveled, commercial-quality steel sheet free of scale, buckle, pits, and other defects. Line entire interior and doors with lead sheet thickness not less than that required for partition in which cabinet is installed **OR** as indicated on Drawings, **as directed**.

a. Configuration and Size: Two-compartment, four-door type with compartments 8 inches wide by 19 inches high by 18-3/4 inches deep (203 mm wide by 483 mm high by 476 mm deep) **OR** 10-1/4 inches wide by 21 inches high by 20 inches deep (260 mm wide by 533 mm high by 508 mm deep), **as directed**, inside.
OR
Configuration and Size: As indicated on Drawings **OR as directed**.

b. Provide an integral flange with lead lining extending beyond rough opening at least 3/4 inch (19 mm).

c. Provide a sound passage in cabinet frame. Offset sound passage to make opening lightproof and to maintain required lead equivalence at all points and in all directions.

d. Doors: Mount doors on full-height, concealed-leaf hinges. Label doors to one compartment "EXPOSED" and to other "UNEXPOSED." Provide a manual interlocking device to prevent doors on opposite sides of compartments from being opened at same time.

e. Exterior Finish: Baked-on gray enamel primer.

f. Cabinet Interior: Provide each compartment with a black rubber floor. Finish interior of doors, sides, and top in a nonreflective black finish.

g. Trim: Provide face flange or separate trim on each side of wall.

h. Hardware: Provide bright, polished, chrome-plated brass hardware.

i. Rough-in Frame: Provide adjustable telescoping rough-in frame fabricated from 0.064-inch- (1.6-mm-) thick, zinc-coated steel. Design frame to allow adjustment for wall thicknesses from approximately 4 to 8 inches (100 to 200 mm).

j. Support Brackets: Provide two support brackets for each cabinet. Provide brackets manufactured from 1-inch (25-mm) OD, 0.065-inch (1.65-mm) wall thickness, anodized aluminum or stainless-steel tubing with satin finish. Provide with fixed- or swivel-type mounting flanges on both ends.
OR
Support Brackets: Provide two triangular support brackets for each cabinet. Brackets shall be manufactured from 0.0428-inch- (1.1-mm-) thick steel sheet with flanges for fastening to wall and to cabinet. Finish with baked-on primer.

H. Neutron-Shielding Doors And Frames

1. General: Steel plate doors lined with lead and borated polyethylene and hung from structural-steel door frames.

a. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.

b. Door Construction: Fabricate from 1/4-inch- (6-mm-) thick steel plate faces, reinforced at hinge locations, and 1/2-inch- (13-mm-) thick, steel flat-bar edges fully welded together. Continuously weld exposed joints and finish smooth, matching adjacent surfaces.

1) Apply filler to interior of door faces to provide smooth, even surfaces for applying lead and polyethylene. Bond lead to interior of door face with permanent adhesive.

2) Install lead in one piece and polyethylene in single or multiple sheets, all full height and width of door interior.

c. Door Frame Construction: Fabricate from 1/4-inch- (6-mm-) thick steel plate to dimensions indicated, fully welded together. Continuously weld exposed joints and finish smooth, matching adjacent surfaces.

1) Fabricate frames with depth equal to thickness of shielding wall in which door is installed. Rabbet frame to receive door and to provide a 4-inch (100-mm) overlap between door edges and remaining frame depth. Make frame faces 4 inches (100 mm) wide with 3/4-inch- (19-mm-) deep backbends.

2) Reinforce frames and drill and tap as needed to accept finish hardware.

3) Provide steel strap anchors using 1/8-by-2-inch- (3-by-50-mm-) wide straps of length required for a minimum 8-inch (200-mm) embedment. Weld anchors to frame members not more than 8 inches (200 mm) from both bottom and top of jambs and from ends of head, and space anchors not more than 24 inches (600 mm) apart.

4) Provide channel-shaped sill fabricated from 1/4-inch- (6-mm-) thick steel plate lined with lead. Make sill 1-1/2 inches (38 mm) deep by same width as jambs and weld to door jambs.

d. Shop-Primed Finish: Prepare ferrous-metal surfaces to comply with SSPC-SP 3 (Power Tool Cleaning) and apply an alkyd primer complying with MPI#79.
   1) Stripe paint corners, crevices, bolts, welds, and sharp edges.

e. Hardware: Provide the following hardware for each door:
   1) Hinges: BHMA A156.1, Type A8391; weld- or bolt-on type at manufacturer's option; sized for door weight; two or three per door at manufacturer's option.
   2) Pulls: BHMA A156.6, Type J401, two per door.
   3) Operator: Power-opening and spring- or power-closing unit; with automatic hold-open; complying with BHMA A156.10; sized for door weight and width; and adjustable for opening, closing, and checking speeds. Unit shall have an emergency release to allow door to be opened manually and a disconnect switch to prevent power operation when door is in emergency-release mode.
   4) Controls: Provide two wall-mounted, recessed, push-plate switches for opening door and one push-button switch for closing door. Provide motion or presence sensors to detect persons or objects in path of door and, if these are detected, to stop and reverse action of door operator.

f. Door Interlock Switch: Provide electric switch in frame jamb to prevent operation of radiation therapy equipment when door is open and to shut off power to equipment if door is opened while equipment is in use.
   1) Provide rough box for installing switch, fabricated from 1/4-inch- (6-mm-) thick steel plate welded to frame and lined on all sides with 1/4-inch- (6-mm-) thick lead plate.

I. Informational Signs
1. Informational Signs, General: Fabricate signs by engraving lettering in high-pressure-laminate engraving stock with contrasting face and core. Machine engrave copy using high-speed cutters mechanically positioned by master templates for accurately formed letters, numbers, and symbols.
   a. Color: As selected from manufacturer's full range of colors.
   b. Provide copy indicated or as directed. Provide signs of sufficient size to contain required information.
   c. Indicate lead equivalence in millimeters and heights of radiation protection in inches (millimeters).
2. Rooms Where the Level of Protection Is Uniform Throughout: Provide one sign for each room indicating lead equivalence of partitions, ceilings, floors, doors, and other portions of radiation protection enclosure. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height.
3. Rooms Where the Level of Protection Is Not Uniform Throughout: Provide one sign for each room with different lead equivalences in different locations. Indicate, in tabular form, lead equivalence of each wall, partition, ceiling, floor, door, and window. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height. Indicate where lead equivalence changes or is not continuous.
4. Rooms Where Some Partitions Are without Radiation Protection: Provide one sign for each partition that contains radiation protection and indicate its lead equivalence. Indicate height of radiation protection above floor or indicate that partitions are radiation protected to full height.
5. Rooms Where Only the Door Has Radiation Protection: Provide one sign for each door indicating its lead equivalence.

J. Door And Door Frame Fabrication
1. Hardware Preparation: Factory prepare doors and frames to receive templated mortised hardware; include cutouts, reinforcement, mortising, drilling, and tapping according to the Door Hardware Schedule and templates furnished as specified in Division 08 Section "Door Hardware".

1.3 EXECUTION

A. Installation Of Lead Sheets In Concrete Floor Slabs
1. Apply a coat of asphalt mastic or paint to concrete surfaces before installing lead sheet.
2. Before installing floor lead sheet, place lead strips not less than 7 inches (175 mm) wide under the base of vertical wall protection. Extend lead strips approximately 3 inches (75 mm) into the shielded room area.
3. Lead Sheet, 1/8 Inch (3 mm) Thick or Less: Install in a single layer with a 2-inch (50-mm) minimum lap at joints.
4. Lead Sheet More Than 1/8 Inch (3 mm) Thick: Install in two or more layers with a 2-inch (50-mm) minimum lap at joints, or in a single layer with joints butted and covered with a 4-inch- (100-mm-) wide lead strip of same thickness.
5. Extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls of room.
OR
In floor slabs above shielded rooms where lead sheet is indicated, extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls of room below.
6. At door openings, extend lead sheet at least 12 inches (300 mm) beyond radiation protection in walls and at least 12 inches (300 mm) beyond door opening on both sides except where lead-lined thresholds are provided.
7. After installation, apply a coat **OR** two coats, **as directed**, of asphalt coating on top surface of lead sheet and protect from damage until concrete topping is placed.

B. Installation Of Lead Bricks
1. Remove projections from concrete surfaces to receive lead bricks and apply one layer of asphalt felt to prevent contact between lead bricks and concrete.
   a. At recesses in concrete floors to receive lead bricks, turn up asphalt felt at perimeter of recess.
2. Install lead bricks to dimensions indicated, tightly fitted together, with joints offset in succeeding courses. Cut bricks neatly at joints with adjacent materials for a snug fit, with edges straight and true and at right angles.
   a. Calk joints between lead bricks and support framing with lead wool.
   b. Install lead strips as indicated at joints between lead bricks and support framing.
   c. Secure lead bricks to walls as indicated with steel flat bars fastened with steel lag bolts driven into lead plugs.
3. After installation, apply a coat of asphalt coating on surfaces of lead bricks that will receive concrete.

C. Installation Of Lead-Lined Concrete Masonry Units
1. Lay units in running bond, using methods recommended in writing by concrete masonry unit manufacturer.
2. Cut units, as needed, without disturbing bond between lead and concrete, and without reducing required lapping margin or shielding qualities.
3. Blocks Designed to Have Lead Laps at Joints: Lay units with tight lead laps without soldering or burning.
4. Blocks Designed to Have Lead Bars in Joints: Lay units with lead bars, of thickness not less than that required in block, in each horizontal and vertical joint. Position bars directly adjacent to lead lining with bars overlapping lead lining at least twice the thickness of lead lining, but not less than 1/2 inch (13 mm).
5. Mortar Joints: Lay units with 1/2-inch (13-mm) solidly filled mortar joints. Keep lead laps free of intervening mortar. Cut joints flush with face of units.
6. Wraparound Metal Frames: Extend units into frame openings with lead lining projecting into rabbets of frames to effectively lap with lead frames or frame linings at least 1 inch (25 mm).
7. Pipe and Conduit Chases: Where pipe and conduit chases occur within blocks, faces can be removed from one side to permit installation. Where necessary to remove lead lining for pipe and conduit installation, install continuous lead sheet and overlap adjoining lead protection at least 1

inch (25 mm). Fill voids around pipe and conduit chases with mortar, finished flush with face of partition. Do not locate pipe and conduit chases directly opposite each other in same partition.

D. Installation Of Lead-Lined Gypsum Lath
1. Install lath with long edges at right angles to supports with lead lining facing supports. Place end joints over supports and stagger joints in alternate courses. Overlap lead extensions on adjacent lath to provide an effective lead lap.
   a. Install so joints in walls do not align with adjacent ceiling joints.
2. Fastening to Metal and Wood Supports: Use screws spaced as recommended in writing by gypsum lath manufacturer. Drive screws through lead tabs and fold tabs over screw heads or apply lead disks over screw heads.
   a. Fasten accessories and trim to supports with screws, using lead tabs or lead disks as specified above for fastening lath.
3. Fastening to Wood Supports: Use lead-headed nails spaced as recommended in writing by gypsum lath manufacturer. Drill pilot holes to prevent deforming nails or distorting lath. Set nail heads flush with lath surface.
   a. Fasten accessories and trim to supports with lead-headed nails as specified above for fastening lath.
4. Openings: Extend lead-lined gypsum lath into frames of openings, lapping lead lining with lead frames or frame linings at least 1 inch (25 mm). Arrange lath around openings so neither horizontal nor vertical joints occur at corners of openings.
5. Control and Expansion Joints: Install lead strip on face of framing, extending across joint, and lap with lead lining of lath.

E. Installation Of Lead-Lined Gypsum Base For Gypsum Veneer Plaster **OR** Board, **as directed**
1. Install with long edge parallel to supports and lead lining facing supports. Provide blocking at end joints. Install using construction adhesive and supplementary fasteners.
2. Fastening to Metal Supports: Use steel drill screws spaced as recommended in writing by gypsum board manufacturer. Install lead strips covering face of framing and wrap around flange to cover points of screws.
   a. Where possible, install lead-lined gypsum board before installing gypsum board on other side of partition, and do not fold lead strips back over inside of flange until after lead-lined gypsum board is applied.
   b. Apply lead disks recessed flush with surface of board over heads of screws securing trim.
3. Fastening to Metal and Wood Supports: Use steel drill screws spaced as recommended in writing by gypsum board manufacturer. Apply lead disks over screw heads and recess flush with surface of board.
   a. Install lead strips, 1-1/2 inches (38 mm) wide minimum and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at intermediate supports.
   b. Apply lead disks recessed flush with surface of board over heads of screws securing trim.
4. Fastening to Wood Supports: Use lead-headed nails spaced as recommended in writing by gypsum board manufacturer. Drill pilot holes to prevent deforming nails or distorting board. Drive nail heads slightly below exposed surface.
   a. Install lead strips, 1-1/2 inches (38 mm) wide minimum and same thickness as lead lining, to face of supports and blocking where joints occur. Secure lead strips with construction adhesive. Provide shims at intermediate supports.
   b. Fasten accessories and trim to wood supports with lead-headed nails as specified above for fastening gypsum board.
5. Two-Layer System: Apply a facing sheet of gypsum board vertically over base sheet using laminating adhesive recommended in writing by gypsum board manufacturer. Offset joints in finish layer from joints in base layer and fasten at top and bottom of sheet to support finish panel until adhesive has set.
   a. Locate fasteners above ceiling or behind wall base and cover fasteners with lead disks recessed flush with surface of board.

6. Openings: Extend lead-lined gypsum board into frames of openings, lapping lead lining with lead frames or frame linings at least 1 inch (25 mm). Arrange board around openings so neither horizontal nor vertical joints occur at corners of openings.
7. Install control and expansion joints where indicated, with appropriate trim accessories. Install lead strip on face of framing, extending across joint, and lap with lead lining of gypsum board.

F. Installation Of Lead-Lined Doors And Door Frames
1. Install lead-lined steel doors and door frames according to Division 08 Section "Steel Doors And Frames".
   a. Apply a coat of asphalt mastic or paint to lead lining in door frames where lead will come in contact with masonry or grout.
2. Install lead-lined wood doors according to Division 08 Section "Flush Wood Doors".
3. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with door manufacturer's written instructions.
4. Frames: Comply with HMMA 840 unless otherwise indicated. Except for frames located in existing walls or partitions, place frames before constructing walls. Set frames accurately in position, plumb, and brace securely until permanent anchors are set.
   a. Provide three anchors per jamb, located adjacent to hinge on hinge jamb and at corresponding heights on strike jamb.
   b. In masonry construction, use wire or T-strap anchors and apply a coat of asphalt mastic or paint to lead lining where lead will come in contact with masonry or grout.
   c. In metal stud construction, use wall anchors attached to studs with screws.
   d. In wood stud construction, use strap anchors attached to studs with screws.
5. If frames are factory-lined, lap lead lining of frames over lining in walls at least 1 inch (25 mm).
6. Lead Lining of Frames: Line inside of frames with lead of thickness not less than that required in doors and walls where frames are used. Form lead to match frame contour, continuous in each jamb and across the head, lapping the stops. Form lead shields around areas prepared to receive hardware. Lap lining over lining in walls at least 1 inch (25 mm).
7. Install doors in frames level and plumb, aligned with frames and with uniform clearance at each edge.
8. Line astragals with lead sheet.
9. Hardware: Line covers, escutcheons, and plates to provide effective shielding at cutouts and penetrations of frames and doors. See Division 08 Section "Door Hardware" for other installation requirements.
10. Touch up damaged finishes with compatible coating after sanding smooth.
11. Operation: Rehang or replace doors that do not swing or operate freely. Check and readjust operating hardware items, leaving doors and frames undamaged and in proper operating condition.

G. Installation Of Lead-Lined Observation Windows
1. Install observation windows according to manufacturer's written installation instructions.
   a. Apply a coat of asphalt mastic or paint to lead lining in frames where lead will come in contact with masonry or grout.
2. Install windows level, plumb, square, true to line, and anchored securely in place to structural support.
3. Install leaded side of frame on radiation side of wall. Lap lead lining of frames over lining in walls at least 1 inch (25 mm).
4. Glazing: Comply with installation requirements in Division 08 Section "Glazing" and with manufacturer's written instructions.

H. Installation Of Lead-Lined Modular Shielding Partitions
1. Install partitions after finishes are complete in spaces where partitions are located. Install according to manufacturer's written instructions and Shop Drawings.
2. Cut and remove wall base where modular shielding partitions meet other walls so partition will fit tightly to wall.

3. Secure partition framing to floor with 1/4-inch (6-mm) expansion anchors 16 inches (400 mm) o.c. and fasten to walls and ceilings as indicated. Brace partitions with tie rods fastened to walls or ceilings as indicated.

I. Installation Of Penetrating Items
1. At penetrations of lead linings, provide lead shields to maintain continuity of protection.
2. Provide lead linings, sleeves, shields, and other protection in thickness not less than that required in assembly being penetrated.
3. Secure shields at penetrations using adhesive or wire ties but not penetrating fasteners unless indicated on Drawings.
4. Film Transfer Cabinets: Where film transfer cabinets occur in lead-lined partitions, line wall flange with lead sheet of same thickness as required for partition where it is located.
5. Outlet Boxes and Conduit: Cover or line with lead sheet lapped over adjacent lead lining at least 1 inch (25 mm). Wrap conduit with lead sheet for a distance of not less than 10 inches (250 mm) from box.
6. Duct Openings: Unless otherwise indicated, line or wrap ducts with lead sheet for distance from partition/ceiling equal to three times the largest opening dimension. Lap lead sheet with adjacent lead lining at least 1 inch (25 mm).
7. Piping: Unless otherwise indicated, wrap piping with lead sheet for a distance of not less than 10 inches (250 mm) from point of penetration.

J. Installation Of Neutron-Shielding Doors And Frames
1. Install frames in concrete forms before concrete is placed. Adjust frames as needed so they are square and within 1/16 inch (1.5 mm) of plumb. Secure frames to forms and brace to resist forces resulting from concrete placement.
2. Install frames in concrete openings and adjust as needed so they are square and within 1/16 inch (1.5 mm) of plumb. Secure frames to concrete and brace to resist forces resulting from weight and movement of shielding door. Grout frames, consolidating grout to solidly fill spaces between frame and opening.
3. Install doors in frames and install door operators, door controls, interlock switches, and other components according to manufacturer's written instructions and Shop Drawings.
4. Touch up damaged primer with compatible coating after sanding smooth.
5. Operation: Rehang or replace doors that do not swing or operate freely. Check and readjust operators and controls for opening, closing, latching, and back-checking speeds and for open- and closed-door positions.

K. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections after radiology equipment has been installed and placed in operating condition.
2. Correct deficiencies in or remove and replace radiation protection that inspection reports indicate does not comply with specified requirements.

L. Protection
1. Lock radiation-protected rooms once doors and locks are installed and limit access to only those persons performing work in the rooms.

END OF SECTION 13091

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SECTION 13111 - CATHODIC PROTECTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for cathodic protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes passive cathodic protection systems that use magnesium or zinc anodes to protect iron and steel piping and tanks.

C. Performance Requirements
1. Delegated Design: Design, supervise, test, and inspect the installation of cathodic protection systems, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
   a. Design cathodic protection for pipelines according to NACE RP0169.
   b. Design cathodic protection for metal underground storage tanks according to NACE RP0285.
2. Survey site and determine soil or water corrosivity (resistivity), current requirements, potential surveys, stray currents, and water chemistry/corrosivity (pH).
3. Select anodes and accessories relevant to level of protection. Design anodes for an estimated life of 15 **OR** 30, **as directed**, years before replacement.
4. Cathodic protection systems shall provide protective potential that complies with referenced NACE standards. Insulators are required if needed to insulate protected metals from other structures.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For cathodic protection. Include plans, evaluations, sections, details, and attachments to other work.
   a. Detail locations of cathodic protection equipment, devices, and outlets, with characteristics and cross-references to products.
   b. Include calculations and details of anode designs.
   c. Include labeling and identifying scheme for wires, cables, and test boxes.
3. Delegated-Design Submittal: For cathodic protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified corrosion engineer responsible for their preparation.
   a. Conduct site tests necessary for design, including soil resistivity, close-interval potential surveys, testing during construction, interference testing, and training of Owner's personnel.
   b. Provide system design calculations, stating the maximum recommended anode current output density, and the rate of gaseous production, if any, at that current density.
4. Coordination Drawings: Plans, drawn to scale, and coordinating connections to piping and tanks.
5. Qualification Data: For qualified professional engineer. Submit evidence of current license, corporate authorization (if applicable) of the engineering business, and NACE certifications.
6. Field quality-control reports.
7. Operation and Maintenance Data: Include the following:
   a. Basic system operation, outlining the step-by-step procedures required for system startup, operation, adjustment of current flow, and shutdown.
   b. Instructions for pipe-to-reference cell and tank-to-reference cell potential measurements and frequency of monitoring.

c. Instructions for dielectric connections, interference and sacrificial-anode bonds; and precautions to ensure safe conditions during repair of pipe, tank or other metallic systems. Instructions shall be neatly bound.
d. Locations of all anodes, test stations, and insulating joints.
e. Structure-to-reference cell potentials as measured during the tests required by "Field Quality Control" Article.
f. Recommendations for maintenance testing, including instructions for pipe-to-reference cell potential measurements and frequency of testing.
g. Precautions to ensure safe conditions during repair of pipe system.

8. Warranty: Sample of special warranty.

E. Quality Assurance

1. Corrosion Engineer Qualifications: A qualified professional engineer who has education and experience in cathodic protection of buried and submerged metal structures and has NACE accreditation or certification as a Corrosion Specialist or Cathodic Protection Specialist.

F. Delivery, Storage, And Handling

1. Protect anodes from exposure to rain and direct sunlight.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace permanent reference electrodes that fail in materials or workmanship within specified warranty period.
   a. Warranty Period: 15 **OR** 30, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Magnesium Anodes, Type II

1. Comply with ASTM B 843.
2. Chemical composition as percent of weight shall be as follows:
   a. Aluminum: 0.010 maximum.
   b. Manganese: 0.50 to 1.3.
   c. Zinc: 0.05 maximum.
   d. Silicon: 0.50 maximum.
   e. Copper: 0.02 maximum.
   f. Nickel: 0.001 maximum.
   g. Iron: 0.03 maximum.
   h. Other Impurities: 0.05 each; 0.3 maximum total.
   i. Magnesium: Remainder.
3. Anode Core: Galvanized steel with anode wire silver-soldered to the core. Connection shall be recessed and epoxy insulated for 600-V rating. Connection shall be covered with heat-shrinkable tubing, and insulation shall be extended over connection.
4. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
5. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:
   a. Hydrated Gypsum: 75 percent.
   b. Bentonite Clay: 20 percent.
   c. Anhydrous Sodium Sulfate: 5 percent.

B. Magnesium/Manganese Alloy Anodes
   1. Chemical composition as percent of weight shall be as follows:
      a. Aluminum: 0.01 maximum.
      b. Manganese: 0.50 to 1.3.
      c. Copper: 0.02 maximum.
      d. Nickel: 0.001 maximum.
      e. Iron: 0.03 maximum.
      f. Other Impurities: 0.05 each; 0.3 maximum total.
      g. Magnesium: Remainder.
   2. Bare Anode Weight: 40 lb (18 kg), not including core, and a nominal length of 60 inches (1520 mm).
   3. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
   4. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:
      a. Hydrated Gypsum: 75 percent.
      b. Bentonite Clay: 20 percent.
      c. Anhydrous Sodium Sulfate: 5 percent.

C. Zinc Anodes For Buried Service, Type Z-1
   1. Comply with ASTM B 418, Type II.
   2. Chemical composition as percent of weight shall be as follows:
      a. Aluminum: 0.005 maximum.
      b. Cadmium: 0.003 maximum.
      c. Iron: 0.0014 maximum.
      d. Zinc: Remainder.
   3. Bare Anode Ingot Weight: 30 lb (13.6 kg), 2 inches (50 mm) square and 30 inches (760 mm) long. Packaged weight of anode bag shall be 70 lb (32 kg).
   4. Anode Wires: Factory-installed cables, with copper conductors, suitable for direct burial; not less than No. 10 AWG with Type THWN insulation according to ASTM D 1248 and NEMA WC 70/ICEA S-95-658; long enough to extend to accompanying junction box without splicing.
   5. Anode Backfill: Backfill materials packaged in water-permeable fabric sack or cardboard container. Anodes shall be factory installed in packaged backfill using methods that result in dense packing of fill with factory-installed anode spacers to ensure centering of anode in packaged anode backfill. Backfill material shall have the following chemical composition by weight:
      a. Hydrated Gypsum: 75 percent.
      b. Bentonite Clay: 20 percent.
      c. Anhydrous Sodium Sulfate: 5 percent.

D. Permanent Reference Electrodes
   1. Copper/copper sulfate (Cu/CuSO4), suitable for direct burial. Electrode shall be guaranteed by supplier for 15 **OR** 30, **as directed**, years' service in the installed environment.

E. Wire And Cable
   1. Anode Header Cable: Single-conductor, Type HMWPE, insulated cable specifically designed for direct-buried dc service in cathodic protection installations.
      a. Conductor: Stranded, annealed, uncoated copper, not less than No. 8 AWG, complying with ASTM B 3 and ASTM B 8.

b. Insulation: High-molecular-weight polyethylene, complying with NEMA WC 70/ICEA S-95-658.
c. Minimum Average Thickness of Insulation: 110 mils (2.8 mm) for Nos. 8 through 2 AWG, and 125 mils (3.2 mm) for Nos. 1 through 4/0 AWG; rated at 600 V.
d. Connectors: Copper-compression type or exothermic welds.

2. Conductors and Cables: Comply with requirements in Division 16 Section "Conductors And Cables".
   a. Bonding Conductors for Joint and Continuity Bonds: Not less than No. 8 AWG, stranded, Type THWN copper conductors.
   b. Flexible Pipe Coupling Bonds: Flexible copper straps with electrical resistance equal to No. 1/0 AWG stranded copper wire and with five holes for five exothermic welds to pipe.
   c. Test Wires: No. 12 AWG, Type THWN copper conductors.
   d. Resistance Wires: No. 16 or No. 22 AWG nickel-chromium wire.
   e. Cables for Installation in Conduit: Type THWN copper conductors.

F. Test Stations
1. Plastic Test Stations: Flush-mounted type, manufactured of high-impact-resistant PVC or polycarbonate with watertight conduit connections and cover and removable terminal board having at least five terminals.
2. Test Station Mounting Enclosures:
   a. Non-Traffic-Area Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes".
   b. Traffic-Area Boxes: Comply with requirements in Division 02 Section "Underground Ducts And Utility Structures". Boxes shall have cast-iron covers with a welded bead legend "CP TEST."

G. Sealing, Potting, And Dielectric Compounds
1. Sealing and Dielectric Insulating Compound: Comply with NACE RP0188. Black, rubber based, soft, permanently pliable, tacky, moldable, and unbacked; 0.125 inch (3 mm) **OR** 0.5 inch (13 mm), **as directed**, thick.
2. Potting Compound: Comply with NACE RP0188. Cast-epoxy, two-package type; fabricated for this purpose and covered with heat-shrinkable tape.
3. Pressure-Sensitive, Vinyl-Plastic Electrical Tape: Comply with UL 510.

H. Exothermic Welding Materials
1. Exothermic Weld Kits: Specifically designed by manufacturer for welding materials and shapes required.
2. Exothermic Weld Caps: Dome of high-density polyethylene, 10-mil (0.254-mm) minimum thickness, filled with mastic and containing a tunnel portion to separate lead wire from exothermic weld.

I. Coating Repair Materials
1. Touchup Coating Materials: Comply with requirements in Division 09 Section "High-performance Coatings" for coating systems for touchup of factory-applied coatings.
2. Adhesive-Applied Coating Materials: Coating materials shall be compatible with factory-applied coating system.
   a. Nominal thickness of coating materials shall be not less than 8 mils (0.2 mm) **OR** 16 mils (0.4 mm) **OR** 24 mils (0.6 mm) **OR** 40 mils (1.0 mm) **OR** 60 mils (1.5 mm), **as directed**, plus or minus 5 percent.
   b. Coating materials shall be one of the following supplied by factory-applied coating system manufacturer:
      1) Polyvinyl-chloride, pressure-sensitive, adhesive tape.
      2) High-density polyethylene/bituminous rubber compound tape.
      3) Butyl rubber tape.
      4) Coal-tar epoxy.

1.3 EXECUTION

A. General Installation Requirements
1. Comply with ANSI/IEEE C2 and NFPA 70.
2. Make connections to ferrous pipe and metal tanks using exothermic welding.
3. Coat welds with the coating repair material and apply an exothermic weld cap.

B. Magnesium Anode Installation
1. Install magnesium anodes at locations that clear obstructions. Install at least 36 inches (900 mm) and no more than 10 feet (3 m) from pipe or tank to be protected. Install in augered holes with top of anode 24 inches (600 mm) below pipe invert elevation **OR** a minimum of 36 inches (900 mm) below finished grade. In soils that will collapse into augered holes, use casing of galvanized sheet steel.
2. Install anodes in a dry condition after plastic or waterproof protective covering has been completely removed from water-permeable permanent container that houses anode metal. Do not use anode-connecting wire for lowering anode into hole. Backfill annular space around anode with fine earth in 6-inch (150-mm) layers; compact each layer using hand tools. Do not strike anode or connecting wire during backfilling and compacting. After backfilling and compacting to within 6 inches (150 mm) of finished grade, pour approximately 5 gal. (20 L) of water into each filled hole. After water has been absorbed by earth, complete backfilling to finished level.
3. If rock strata are encountered before achieving specified augured hole depth, install anodes horizontally at depth at least as deep as bottom of pipe to be protected.
4. Install anodes spaced as indicated, directly connected **OR** connected through a test station, **as directed**, to the pipeline, allowing slack in connecting wire to compensate for movement during backfill operation.
5. For tank protection, connect groups of anodes to collector cable. Make contact, through a test station, with tank to be protected.
6. Do not use resistance wires to reduce current output of individual or group anodes.

C. Zinc Anode Installation
1. Install zinc anode horizontally in a hole at least 3 inches (76 mm) larger than anode. Install anode under new copper water tubing, including service lines, blowoffs, and air releases. Separate piping and anode by at least 24 inches (600 mm), but not more than 60 inches (1520 mm).
2. Install anode midway between both ends of piping. Install anode wire in piping trench and connect to piping at an accessible location. Install anode wire in PVC conduit where rising out of the ground to the aboveground connection.

D. Installation Of Reference Electrodes
1. Install directly beneath the buried metallic component being protected.

E. Cable And Wire Installation
1. Install conductors, except anode wires, in PVC conduit with waterproof PVC junction boxes. Comply with requirements in Division 16 Section "Raceways And Boxes" for conduit and its installation.
2. Anode Wire Installation: Cover trench bottom for the anode wire with 3-inch (76-mm) layer of sand or stone-free earth. Center wire on backfill layer and do not stretch or kink the conductor. Place backfill over wire in layers not exceeding 6 inches (150 mm) deep, and compact each layer. Use clean fill, free from roots, vegetable matter, and refuse. Place cable underground-line warning tape within 18 inches (460 mm) of finished grade, above cable and conduit.
3. Bonding Conductors: Install conductors on metallic pipe and tanks, to and across buried flexible couplings, mechanical joints, and flanged joints except at places where insulating joints are specified. Welded and threaded joints are considered electrically continuous and do not require bonding.
   a. Install at least two bonds between parts requiring bonding.

b. Bonding conductors must contain sufficient slack for anticipated movement between structures. Bonding conductors across pipe joints shall have not less than a 4-inch (100-mm) slack for pipe expansion, contraction, and soil stress.
c. Connect bonding conductors to pipe, coupling follower rings and coupling middle ring or sleeve. Connect bonding conductors with exothermic welds.

4. For wire splicing, use compression connectors or exothermic welds.

F. Test Stations
1. Install test stations as follows:
a. At 1000-foot (300-m) intervals.
b. At insulating joints.
c. At both ends of casings when casing material is included in the cathodic protection system.
d. Where pipe crosses other metal pipes.
e. Where pipe connects to existing piping system.
f. Where pipe connects to dissimilar metal pipe.
g. At each tank component.
2. Install test stations on backfill complying with requirements for trench bottom fill for anode wires unless otherwise indicated.
3. Terminate test conductors on terminal boards and install a spare set of test leads at each testing location.

G. Pipe Joints
1. Insulating Flange Sets: Cover flanges with sealing and dielectric compound.
2. Insulating Unions: Install electrical isolation at each building entrance and at other locations indicated on approved Delegated-Design Drawings. Cover unions with sealing and dielectric compound.

H. Insulating Pipe Sleeves
1. Install insulating sleeves between metallic piping and metal buildings, hangers, supports, and other metal structures. Completely surround the metallic pipe for the full length of the steel contact and effectively prevent contact between the cathodically protected metallic pipe and other metallic structures. Support insulating sleeve to prevent damage to coating and to accommodate relative movement, vibrations, and temperature differentials.

I. Dissimilar Metals
1. Underground Dissimilar Piping: Coat insulating joint and pipe at joints of dissimilar piping material with sealing and dielectric compound for a minimum distance of 10 pipe diameters on both sides of joint.
2. Underground Dissimilar Valves: Coat dissimilar ferrous valves and pipe with sealing and dielectric compound for a minimum distance of 10 pipe diameters on both sides of valve.
3. Aboveground Dissimilar Pipe and Valves: If dissimilar metal pipe joints and valves are not buried and are exposed only to atmosphere, coat connection or valve, including pipe, with sealing and dielectric compound for a minimum distance of three pipe diameters on both sides of junction.

J. Coatings
1. Field Joints: Apply adhesive-applied coating system in a thickness to achieve corrosion protection equal to adjacent factory-applied coating.

K. Identification
1. Comply with requirements in Division 16 Section "Electrical Identification".
a. Identify anode wires and anode header cables with marker tape.
b. Identify underground wires and cables with underground-line warning tape.
c. Identify text boxes with engraved, laminated acrylic or melamine label, permanently attached to text box.

L. Field Quality Control
1. Comply with NACE RP0169 and NACE RP0285.
2. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
   a. Static Pull Test: Choose, at random, one completed anode of each type for this destructive test. Demonstrate that anode wire connections have enough strength to withstand a minimum tensile load of 300 lb (136 kg). If test fails, replace all anodes and repeat test at another randomly selected anode.
   b. Insulation Testing: Before anode system is connected to pipe and tank, test insulation at each insulating joint and fitting. Demonstrate that no metallic contact, or short circuit, exists between the two insulated sections of pipe and tank. Replace defective joints or fittings.
   c. Bonding Tests: Test for electrical continuity across all bonded joints. Repair or add additional bonds until electrical continuity is achieved.
   d. Baseline Potentials: After backfilling of pipe, tank, and anodes is completed, but before anodes are connected to pipe and tank, measure the static potential of pipe and tank to soil. Record initial measurements.
   e. Anode Output: Measure electrical current as anodes or groups of anodes are connected to pipe and tank. Use a low-resistance ammeter. Record current, date, time, and location of each measurement.
   f. Pipe- and- Tank-to-Reference Electrode Potential Measurements: On completion of installation of entire cathodic protection system, make electrode potential measurements according to NACE RP0169, using a copper/copper-sulfate reference electrode and a potentiometer-voltmeter, or a dc voltmeter with an internal resistance (sensitivity) of not less than 100,000 ohms per volt and a full scale of 1 or 2 V. Make measurements at same locations as those used for baseline potentials. Record voltage, date, time, and location of each measurement, using one of the following two methods:
      1) 0.85 V Negative Voltage: With cathodic system in operation, measure a negative voltage of at least minus 0.85 V between pipe or tank and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe or tank.
      2) 100-mV Polarization Voltage: Determine polarization voltage shift by interrupting protective current and measuring polarization decay. An immediate voltage shift will occur if protective current is interrupted. Use voltage reading, after immediate shift, as base reading from which to measure polarization decay. Measure at least a minimum polarization voltage shift of 100 mV between pipe or tank and a saturated copper/copper-sulfate reference electrode contacting the earth directly over pipe or tank.
4. Location of Measurements for Piping: For coated piping or conduit, measure from reference electrode in contact with the earth directly over pipe. Measure at intervals not exceeding 400 feet (120 m). Make additional measurements at each distribution service riser, with reference electrode placed directly over service line.
5. Location of Measurements for Tanks: For underground tanks, measure from reference electrode located as follows:
   a. Directly over center of tank.
   b. At a point directly over tank and midway between each pair of anodes.
   c. At each end of tank.
6. Interference Testing: Test interference with cathodic protection from any foreign pipes and tanks in cooperation with Owner of foreign pipes and tanks. Report results and recommendations.
7. Stray Current Measurements: Perform at each test station. Mitigate stray currents due to lightning or overhead ac power transmission lines as provided for in NACE standards.
8. Inspect coatings; comply with NACE RP0188. Repair imperfections of factory-applied coatings as specified in "Coatings" Article.

a. Use electronic holiday detectors to detect coating imperfections.
b. All damage to the protective coating during transit and handling shall be repaired before installation.
c. Repair factory-applied coatings to have equal or better corrosion resistance than the factory-applied coating system. Field-repair material shall be of the type approved by, and shall be applied as recommended by, manufacturer of the coating material.

M. Adjusting
1. Adjust cathodic current using resistors as recommended by corrosion engineer who prepared the Delegated-Design Submittal in Part 1.1.
2. During the first year after Substantial Completion, test, inspect, and adjust cathodic protection system every three months to ensure its continued compliance with specified requirements.

N. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain cathodic protection system.

END OF SECTION 13111

SECTION 13281 - DISPOSAL OF HAZARDOUS MATERIALS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for disposal of hazardous materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definition

1. Hazardous materials shall be defined as asbestos containing materials, lead-based paint, PCBs, bird waste, and other materials categorized as hazardous by the EPA.

C. Submittals

1. Before start of work: At the pre-construction meeting, the Contractor shall submit the following to the Owner's Representative for review. Do not start work until these submittal are returned with Owner's Representative stamp indicating that the submittal is returned for unrestricted use.
   a. Copy of State or local license for hazardous waste hauler.
   b. Certificate of at least one on-site supervisor which has satisfactorily completed the OSHA 40 hour Health and Safety course for handling hazardous materials.
   c. Certificates of workers which have successfully completed the OSHA 40-Hour Health and Safety Course for Hazardous Materials.
   d. List of the employees scheduled to perform this work.
   e. Schedule of start and finish times and dates for this work.
   f. Name and address of landfill where these waste materials are to be deposited. Include contact person and telephone number.
   g. Material Safety Data Sheet (MSDS) for all materials to be removed.
   h. If contractor introduces any chemical into the work environment, a MSDS for that chemical must be presented to the Owner's Representative prior to use.
   i. Transporter must have notified the EPA and/or other appropriate local government agency in advance of its intentions to transport hazardous materials and, if applicable, receive an identification number.
   j. Contingency Plan for handling emergencies with spills or leaks.
   k. Certificates of workers which have successfully completed the OSHA 24-Hour Health and Safety Course for Hazardous Materials.

1.2 PRODUCTS

A. Materials

1. Drums: Recovery or salvage drums acceptable for disposal of hazardous waste. Prior approval of drums is required. Drums or containers must meet the required OSHA, EPA (40 CFR Parts 264-264 and 300), and DOT Regulations (49 CFR Parts 171-178). Use of damaged containers shall not be allowed.
2. Labels: As required by the EPA and OSHA for handling, transportation, and disposal of hazardous waste.
3. Absorbent Material: Clay, soil or any commercially available absorbent used for the purpose of absorbing hazardous or potentially hazardous materials.

1.3 EXECUTION

A. All waste shall be transported and disposed of in accordance with all federal, state and local guidelines and regulations. The contractor is to obtain all permits, licenses, etc., which are necessary for the transporting and disposal of hazardous waste.

B. Waste haulers shall maintain waste manifest and shipment record forms.

END OF SECTION 13281

SECTION 13281a - REMOVAL OF FRIABLE ASBESTOS-CONTAINING MATERIALS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for removal of friable asbestos-containing materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Description

1. Furnish all labor, materials, facilities, equipment, services, employee training and testing, permits and agreements necessary to perform the work required for asbestos removal, encapsulation, repair, clean-up, decontamination, re-insulation and all other work in accordance with these specifications, in accordance with the latest regulations from the U.S. Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the recommendations of National Institute of Occupational Safety and Health (NIOSH), and any other applicable federal, state and local government regulations. Whenever there is a conflict or overlap of the above references, the most stringent provision is applicable.
2. The work specified herein shall be performed by competent persons trained, knowledgeable and qualified in the state-of-the-art techniques of asbestos abatement, handling and subsequent cleaning of contaminated areas.

C. Scope

1. The quantities of materials and limits of abatement work area(s) shall be verified by the asbestos contractor.

D. Asbestos Hazard

1. Asbestos-containing material when damaged or disturbed is subject to fiber releases. Wet methods are a primary means of controlling fiber release.
2. Strict compliance with each of the provisions outlined in these specifications for the encapsulation, repair and handling of asbestos-containing material is of great importance, because:
   a. The inhalation of airborne asbestos fibers can cause a very serious and often fatal disease.
   b. Workers may not be aware they are inhaling asbestos fibers.
   c. Symptoms of the disease do not appear for many years.
   d. Only the Contractor and his employees can prevent the inhalation of asbestos fibers, which can lead to the development of asbestos-related disease.
   e. No insurance is available to provide for asbestos-related disease.

E. Other Hazardous Material

1. Contractor shall comply with OSHA 29 CFR 1926.62 - Lead in Construction when demolishing any equipment or architectural component identified as lead-containing or lead-based paint. The work of this project is considered a demolition activity.
2. The Owner anticipates that a substantial amount of the Project will involve lead paint.

F. Qualifications

1. The Owner and the Owner's Representative will verify and approve the experience of the Asbestos Abatement Contractor based upon submission at the time of bidding by Contractor evidence of the following:
   a. Experience: Provide the names and locations of at least three asbestos abatement projects of comparable size and complexity comparable with this work. Provide the names and telephone numbers of contact person at previous projects. Provide the final air monitoring decontamination fiber levels achieved.

b. Personnel: Provide the name(s) of "Competent Person" as defined by OSHA 29 CFR 1926.32(f) - Asbestos. Demonstrate the education and specialized training with successful completion of examination of an EPA approved course. Provide evidence of participation in five projects of complexity comparable with this project.

c. Licensing and Certification: The Contractor must hold a current, valid asbestos license issued by the State in which the work is to be performed.

G. Notices And Record Keeping

1. Contractor shall maintain for at least 30 years, a record for each asbestos project in which the Contractor engages. Each record shall include the following information: name, address, and social security number of all personnel involved with the project, the name address and social security number of the OSHA "Competent Person" who will supervise the work, the amount of asbestos material that was removed, repaired, encapsulated or disturbed, the commencement and completion date of the work, copies of Hazardous Waste Manifest(s), personal air monitoring results and any other appropriate information.

2. The Contractor shall send written notification as required by USEPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61, Subpart M) to the Owner, at least 10 working days prior to beginning any work on asbestos-containing materials.

3. Include the following information:

a. Name and address of Owner or operator.

b. Description of the facility being demolished or renovated, including the size, age, and prior use of the facility.

c. Estimate of the approximate amount of asbestos material present in the facility in terms of linear feet of pipe, and surface area on other facility components. For facilities in which the amount of asbestos materials is less than 80 linear meters (260 linear feet) on pipes and less than 15 square meters (160 square feet) on other facility components, explain techniques of estimation.

d. Location of the facility being demolished or renovated.

e. Scheduled starting and completion dates of demolition or renovation.

f. Nature of planned demolition or renovation and method(s) to be used.

g. Procedures to be used to comply with the requirements of USEPA National Emission Standards for Hazardous Air Pollutants (NESHAPS) Asbestos Regulations (40 CFR 61 Subpart M).

h. Name and location of the waste disposal site where the asbestos waste material will be deposited.

4. Prior to commencement of work, the Contractor shall submit the following documents to the Owner's Representative. No work will be allowed to start until these documents have been approved:

a. The schedule of the work, including manpower, length and number of work shifts. Schedule shall be coordinated with the Owner's full occupancy of all areas of the building.

b. Satisfactory proof that written notification has been provided to the EPA regional office and the Owner.

c. Proof that all required permits, disposal site locations, and arrangements for transportation and disposal of asbestos-contaminated materials, supplies and the like have been obtained.

d. Complete a worker certificate indicating that all employees have had instruction and training on the hazards of asbestos exposure, the use and fitting of respirators, protective dress, wet and dry decontamination procedures, entry and exit from work areas, and all aspects of work procedures and protective measures.

e. Documentation indicating that all employees have received appropriate medical examinations and have successfully passed fit testing for the respirator to be worn. As a minimum, medical exams must be consistent with OSHA 29 CFR 1926.1101(K)(9)(viii)(G)-Asbestos Regulation.

f. Samples of signs to be used in and around the work area to comply with 0SHA 29 CFR 1926.1101(K)(9)(viii)(I)- Asbestos regulations and as required by federal, state and municipal regulations.
g. Material Safety Data Sheets (OSHA form 174 or equivalent) for all chemicals used during work performed under this section.
h. Encapsulation data and encapsulation procedures.
i. Design of pressure differential system including calculation used to arrive at the number of machines necessary to achieve one air change per every 10 minutes.
j. Location of personnel and material decontamination units for each work area.

5. Contractor shall provide written notification to the Owner's Representative of his intent to start work at least five days in advance. In no case will the Contractor start work until authorization to proceed is given.
6. During the work, Contractor shall maintain a daily log which will be kept at the job site. Items to be included in the daily log shall include but are not limited to the following:
   a. Meetings, purpose, attendees, discussions, items of resolution.
   b. Visitations, authorized and unauthorized.
   c. Sign-in sheets of all personnel entering and leaving the work area.
   d. Special or unusual events (i.e., barrier breeching equipment failures).
   e. Personal air monitoring results.
   f. Two copies of the daily log are required for Project Closeout.

H. Terminology (Definitions)

1. Abatement - Procedures to control fiber release from asbestos-containing materials. Includes removal, enclosure or encapsulation.
2. Air Lock - A system for permitting ingress or egress without permitting air movement between any two adjacent areas consisting of two curtained doorways. The air lock must be maintained in an uncontaminated condition at all times.
3. Air Monitoring; - The process of measuring the asbestos fiber content of a specific volume of air in a stated period of time using methods approved or recommended by OSHA, EPA, NIOSH or other method approved by the Owner or the Owner's Representative.
4. Amended water - Water to which a surfactant has been added.
5. Asbestos - A generic name given to a number of naturally occurring hydrated mineral silicates that possess a unique crystalline structure, are incombustible in air, and are separable into fibers. Asbestos includes the asbestiform varieties of Chrysotile (serpentine), Crocidolite (Riebeckite), Amosite (Cummingtonite-Grunente), Anthophyllite, Actinolite, and Tremolite.
6. Asbestos-containing. material (ACM) - Any material that contains more than 1 percent asbestos by weight as determined by Polarized Light Microscopy (PLM).
7. Authorized Visitor - The Owner or his designated representative, or a representative of any regulatory or other agency having jurisdiction over the project.
8. Class I - Asbestos work means activities involving the removal of thermal systems insulation (TSI) and surfacing ACM and PACM.
9. Class II - Asbestos work means activities involving the removal of ACM which is not TSI or surfacing material. This includes, but is not limited to, the removal of asbestos-containing wallboard, floor tile and sheeting, roofing and siding shingles, and construction mastics.
10. Class III - Asbestos work means repair and maintenance operations where "ACM" including TSI and surfacing ACM and PACM is likely to be disturbed.
11. Class IV - Asbestos work means maintenance and custodial activities during which employees contact but do not disturb ACM or PACM and activities to clean-up dust, waste and debris resulting from Class I, II and III activities.
12. Critical Barrier - A unit of temporary construction which provides the only separation between an asbestos work area and an adjacent, potentially occupied, space. The critical barrier is composed of at least one intact sheet of polyethylene sheeting.
13. Decontamination Enclosure System - A series of connected rooms with curtained doorways between any two adjacent rooms, for the decontamination of workers or of materials and equipment. A decontamination system contains at least two air locks.

14. Disposal - All procedures necessary to transport and deposit the asbestos-contaminated material stripped and removed from the building in a waste disposal site in compliance with applicable federal, state, and local regulations.
15. Disposal Site - A site approved by the EPA for the disposal of asbestos-containing wastes.
16. Encapsulant - A liquid which can be applied to asbestos-containing materials and which controls the possible release of fibers from the materials.
17. Encapsulation - The use of an agent to seal the surface (bridging encapsulant) or penetrate the bulk (penetrating encapsulant) of the asbestos-containing material.
18. HEPA -High Efficiency Particulate Air - A type of filter which is 99.97% efficient at filtering particles of 0.3 micrometers in diameter.
19. HEPA Vacuum Equipment - Vacuuming equipment equipped with a HEPA filter in the exhaust outlet, and so designed and maintained that 99.97% of all particles of 0.3 micrometer in diameter in the inlet air are collected and retained.
20. Negative Pressure Respirators - Respirators which function by the wearer breathing in air through a filter.
21. NIOSH - National Institute of Occupational Safety and Heath.
22. Owner's Representative - Authorized Consultants
23. Permissible Exposure Level (PEL) - A level of airborne fibers specified by OSHA as an occupational exposure standard for asbestos. It is 0.1 f/cc of air, eight-hour TWA, as measured by Phase Contrast Microscopy.
24. Repair - The restoration of damaged or deteriorated asbestos-containing material to intact condition.
25. Respirator Protection Program - A set of procedures and equipment required by OSHA if employees wear negative pressure respirators or if fiber levels are above the PEL.
26. Surfactant - Chemical wetting agent added to water to improve penetration, thus reducing the amount of water required for a given operation or area, and enhancing the effect of the water in reducing fiber release.
27. Thermal Systems Insulation - Material applied to pipes, fittings, boilers, breeching, tanks, ducts or other interior structural components to prevent heat loss or gain, or water condensation, or for other purposes.
28. Wet Cleaning - The process of eliminating asbestos contamination from building surfaces and objects by using cloths and mops or other cleaning tools that have been dampened with clean water and afterwards disposing of these cleaning tools as asbestos-contaminated waste.

I. Permits And Licenses:
1. The Contractor must maintain current licenses as required by applicable state or local jurisdictions for the removal, transporting, disposal or other regulated activity relative to the work of this contract.

J. Regulations
1. This section sets forth governmental regulations and industry standards which are included and incorporated herein by reference and made a part of the specifications. This section also sets forth those notices and permits which are known to the Owner and which either must be applied for and received, or which must be given to governmental agencies before start of work.
2. Except to the extent that more explicit or more stringent requirements are written directly into the contract documents, all applicable codes, regulations, and standards have the same force and effect (and are made a part of the contract documents by reference) as if copied directly into the contract documents, or as if published copies are bound herewith.
3. The Contractor shall assume full responsibility and liability for the compliance with all applicable federal, state, and local regulations pertaining to work practices, hauling, disposal, and protection of workers, visitors to the site, and persons occupying areas adjacent to the site. The Contractor is responsible for providing medical examinations and maintaining medical records of personnel as required by the applicable federal, state, and local regulations. The Contractor shall hold the Owner and the Owner's Representative harmless for failure to comply with any applicable work,

hauling, disposal, safety, health or other regulation on the part of himself, his employees, or his Sub-Contractors.

4. Federal requirements which govern asbestos abatement work or hauling and disposal of asbestos waste materials include but are not limited to the following regulations:
   a. U.S. Department of Labor, Occupational Safety and Health Administration, (OSHA), including but not limited to:
      1) U.S. Department of Labor, OSHA, including, but not limited to:
         a) Occupational Exposure to Asbestos, Tremolite, Anthophyllite and Actinolite; Final Rules
            Title 29, Part 1910, Section 1001
            Part 1926, Section 1101 of the Code of Federal Regulations
         b) Respiratory Protection
            Title 29, Part 1910, Section 134 of the Code of Federal Regulations
         c) Construction Industry
            Title 29, Part 1926.1011, of the Code of Federal Regulation
         d) Access to Employee Exposure and Medical Records
            Title 29, Part 1910, Section 2 of the Code of Federal Regulations
         e) Hazard Communication
            Title 29, Part 1910, Section 1200 of the Code of Federal Regulations
         f) Specifications for Accident Prevention Signs and Tags
            Title 29, Part 1910, Section 145 of the Code of Federal Regulations
      2) U.S. Environmental Protection Agency (EPA) including, but not limited to:
         a) Asbestos Abatement Projects Rule
            40 CFR Part 762
            CPTS 62044, FRL 2843-9
            Federal Register, Vol. 50 No. 134, July 12,1985
            P28530-28540
         b) Regulation for Asbestos
            Title 40, Part 61, Subpart A of the Code of Federal Regulations
         c) National Emission Standard for Asbestos
            Title 40, Part 61, Subpart M (Revised Subpart B) of the Code of Federal Regulations
      3) State requirements which govern asbestos abatement work and/or hauling and disposal of asbestos waste materials.
      4) Contractor shall abide by all local requirements which govern asbestos abatement work or hauling and disposal of asbestos waste materials including the following:
         a) American National Standards Institute (ANSI)
            1430 Broadway
            New York, NY 10018
            (212) 354-3300
         b) Fundamentals Governing the Design and Operation of Local Exhaust Systems Publication Z9.2-79
         c) Practices for Respiratory Protection Publication Z288.2-80
         d) American Society for Testing and Materials (ASTM)
            1916 Race Street
            Philadelphia, PA 19103
            (215) 299-5400
         e) Specification for Encapsulants for Friable Asbestos-Containing Building Materials
         f) Safety and Health Requirements Relating to Occupational Exposure to Asbestos

K. Owner's Representative
   1. The Owner's Representative is authorized by the Owner to perform the following:
      a. Have free access to all asbestos work areas.

b. To assist in interpretation of procedures.
c. To advise on all provisions of the contract documents pertaining to the control of asbestos.
d. To stop work if, in the course of performing their monitoring duties, an instance of substantial nonconformance with the contract documents is observed.
e. To stop work if a situation presenting a health hazard to workers or the Owner's employees or occupants of the building is observed.
f. To act as the Owner's liaison in technical matters involving the asbestos-related work.
g. To perform air sampling inside and outside the asbestos work area during the project. The Contractor shall cooperate fully with Owner's Representative, its agents and employees, and ensure cooperation of his/her workers during collection of air samples and work area inspections.
h. The Owner's Representative role in advising the Owner on environmental health matters does not relieve the Contractor's obligation to comply with all applicable health and safety regulations. Air monitoring results generated by Owner's Representative shall not be used by the Contractor to represent compliance with regulatory agency requirements for monitoring of worker's exposure to airborne asbestos, nor shall any other activity on the part of Owner's Representative represent the Contractor's compliance with applicable health and safety regulations.

L. Pre-Construction Conference
1. An initial progress meeting recognized as "Pre-Construction Conference" shall be held prior to start of any work. Contractor shall meet at project site, with General Superintendent, the Owner, the Owner's Representative, and other entities concerned with asbestos abatement work. Record discussions and agreements and furnish copy to each participant. Provide at least 72 hours advance notice to all participants prior to convening Pre-Construction Conference.
2. This is an organizational meeting, to review responsibilities and personnel assignments, to locate the containment and decontamination areas; and temporary facilities including power, light, water, etc.
3. Submit waivers on forms, and executed in a manner acceptable to the Owner. Administrative requirements that must proceed or coincide with Contractor's submittal for final payment shall consist of the following:
a. Completion of project closeout requirements.
b. Completion of items specified for completion beyond time of substantial completion (regardless of whether special payment application was previously made).
c. Assurance, satisfactory to the Owner, that unsettled claims will be settled and that work not actually completed and accepted will be completed without undue delay.
d. Transmittal of required project construction records to the Owner.
e. Landfill receipts for all asbestos-containing material.
f. Proof, satisfactory to the Owner, that taxes, fees and similar obligations of Contractor have been paid.
g. Removal of temporary facilities, services, surplus materials, rubbish and similar elements.
h. Consent of surety for final payment.

M. Project Closeout
1. Project closeout is the term used to describe certain collective project requirements that indicate completion of the work to be fulfilled near the end of the contract time. Also, in preparation for final acceptance of the work by the Owner, as well as, final payment to the Contractor and the normal termination of the Contract.
2. Include supporting documentation for completion as indicated in these contract documents.
3. Submit a statement on accounting of changes to the Contract Sum.
4. Advise the Owner of pending insurance change-over requirements.
5. Submit specific warranties, workmanship and maintenance bonds, maintenance agreements, final certifications and similar documents.

6. Obtain and submit releases enabling the Owner's full, unrestricted use of the work area and access to services and utilities. Where required, include occupancy permits, operating certificates and similar releases.
7. Results of the completed inspection will form the initial "punch-list" for final acceptance.
8. A complete record, certified by the testing laboratory, of all personal air monitoring results.
9. Complete the following cleaning operations as outlined in Paragraph “Decontamination Procedures” before requesting the Owner's Representative inspection for certification of substantial completion.
    a. Remove exposed labels in finished spaces which are not required as permanent labels on materials supplied as part of the work, except for "Asbestos", "Asbestos Free", or Thermal Insulation Labels specified elsewhere.
    b. Clean transparent materials, affected by the work including mirrors and window/door glass, to a polished condition, removing substances which are noticeably vision-obscuring materials. Replace broken glass and damaged transparent materials.
    c. Clean exposed hard-surfaced finishes affected by the work, to a dirt-free condition, free of dust, stains, films and similar distracting substances. Except as otherwise indicated, avoid disturbance of natural weathering of exterior surfaces. Restore reflective surfaces to original reflective condition.
    d. Clean plumbing fixtures affected by the work to a sanitary condition, free of stains including those resulting from water exposure.
    e. Replace all HVAC filters using materials supplied by the Owner or clean non-replaceable filters after minimum of two days of operation of HVAC equipment.
    f. Clean light fixtures and lamps, which have been affected by the work so as to function with full efficiency. Replace lamps where inoperable.
    g. Repair any damage to wall, ceiling and floor surfaces caused by installation and removal of the polyethylene sheeting.

N. Personnel Protection
1. Prior to commencement of work, the workers shall be instructed and be knowledgeable in the areas described in Paragraph "Submittals and Notices" having to do with employees.
2. Worker Protection - shall comply with 29 CFR 1910.134 (Respiratory Protection).
    a. Because there is no known safe level of exposure to asbestos, it is prudent to reduce worker's exposures to as low a level as possible. Proper respiratory protection is critical in minimizing exposure.
    b. Workers shall be provided, as a minimum, with personally issued and marked respirators equipped with high efficiency particulate filters approved by NIOSH to be worn in the designated work area and/or whenever a potential exposure to asbestos exists. Sufficient filters shall be provided for replacement as required by the workers or applicable regulations. Disposable respirators shall not be used.
    c. No worker shall be exposed to levels greater than 0.01 f/cc as determined by the protection factor of the respirator worn and the work area fiber levels.
    d. Whenever powered purifying respirator protection is used, a sufficient supply of replacement batteries and HEPA filter cartridges shall be provided to the workers.
    e. Air monitoring required by OSHA is work of the Contractor and not covered in this specification. Contractor shall post, on a daily basis, results of the air monitoring results from the previous shift. A complete record, certified by the testing laboratory, of all personal air monitoring tests and results will be furnished to the Owner and the Owner's Representative prior to Contractor's Request for Final Payment.
    f. During encapsulation operations or usage of other organic base aerosols (e.g., spray glue, expanding foam), workers shall be provided with combination cartridges consisting of organic vapor and HEPA sections.
    g. Workers shall be provided with sufficient sets of protective full-body clothing to be worn in the designated work area and/or whenever potential exposure to asbestos exists. Such clothing shall include, but not be limited to, full-body coveralls, headgear and gloves. Workers shall assure that hoods covering their hair are worn in the designated work areas

at all times. Eye protection and hard hats shall be provided as required by applicable safety regulations. Eye protection shall be worn during encapsulation operations. Non-disposable type protective clothing and footwear shall be left in the work area until the end of the asbestos abatement work, at which time such items will be disposed of as asbestos waste.

h. Non-skid footwear shall be provided to all abatement workers. Disposable clothing shall be adequately sealed to the footwear to prevent body contamination.

i. Protective clothing shall not be worn in lieu of street clothing outside the work area.

j. Visitor Clothing: The Contractor shall provide authorized visitors with suitable respirator, protective clothing, headgear, eye protection, and footwear as described herein, whenever they enter the work area.

3. Decontamination and Work Procedures: The decontamination and work procedures to be followed by workers shall be posted as described in these specifications.

4. Worker and Authorized Visitor Protection Procedures:

a. Each worker and authorized visitor shall, upon entering the job site, remove street clothes in a designated clean change area and put on a respirator with new filters and clean protective clothing before entering the work area.

b. The Contractor's employees shall perform a positive/negative respirator fit test each time he enters the work area. If leakage occurs, the respirator must be re-adjusted or replaced.

c. Workers shall maintain their respirators in a safe operating condition. The condition of respirators shall be checked daily.

d. Workers and visitors shall complete the decontamination procedures as outlined in the specification upon exiting the work area.

e. Workers shall not eat, drink, smoke, or chew gum or tobacco in or near the asbestos work areas.

f. Workers shall be fully protected with respirators and protective clothing immediately prior to the first disturbance of asbestos-containing or contaminated materials and until final cleanup is completed.

O. Air Monitoring

1. The airborne fiber counts outside the work area will be monitored to detect faults in the work area isolation such as contamination of the building outside of the work areas with airborne asbestos fibers, failure of filtration or rupture in the negative pressure system.

   Should any of the above occur, the Contractor shall immediately cease asbestos abatement activities until the fault is corrected. Work shall not recommence until authorized by Owner's Representative. In the case of mini-enclosures the Owner's Representative will monitor air in a remote location of the residence to determine the baseline of asbestos.

2. The airborne fiber counts in the work area will be monitored. The purpose of this air monitoring will be to detect airborne fiber counts which may significantly challenge the ability of the work area isolation procedures to protect the balance of the building or outside of the building from contamination by airborne fibers. In the case of mini-enclosures the Owner's representative may monitor air outside of several enclosures if they are in close proximity.

3. Contractor shall maintain an average airborne count inside the work area of less than 0.5 f/cc. If the fiber counts rise above this figure for any sample taken, revise work procedures to lower fiber counts. If the TWA fiber count for any work shift or eight-hour period exceeds 0.5 f/cc, stop all work, leave pressure differential system in operation and notify Owner's Representative. Do not recommence work until authorized in writing by Owner's Representative.

4. If airborne fiber counts exceed 1.0 f/cc for any period of time cease all work until fiber counts fall below 0.5 f/cc and notify Owner's Representative. Do not recommence work until authorized in writing by the Owner's Representative.

5. If any air sample taken outside of the work area exceeds the 0.01 f/cc of air, Contractor shall immediately and automatically stop all work. If this air sample was taken inside the building and outside of critical barriers around the work area, immediately erect new critical barriers to isolate the affected area from the balance of the building. Erect Critical Barriers at the next existing structural isolation of the involved space (e.g., wall, ceiling, and floor). Leave Critical Barriers in

place until completion of work and insure that the operation of the negative pressure system in the work area results in a flow of air from the balance of the building into the affected area.

6. If the exit from the clean room of the personnel decontamination unit enters the affected area, establish a temporary decontamination facility consisting of a shower room and changing room. After cleaning and decontamination of the affected area remove the shower room and leave the changing room in place as an air lock.
7. After certification of visual inspection in the work area, remove critical barriers separating the work area from the affected area. Final air samples will be taken within the entire area.
8. The following procedure will be used to resolve any disputes regarding fiber types when a project has been stopped due to excessive airborne fiber counts. "Airborne Fibers" referred to above include all fibers regardless of composition as counted in the Phase Contrast Microscopy (PCM) NIOSH 7400 Method procedures. If work has stopped due to high airborne fiber counts, air samples will be secured in the same area by the Owner's Representative for analysis by electron microscopy. "Airborne fibers" counted in samples analyzed by Scanning or Transmission Electron Microscopy (TEM) shall be only asbestos fibers, but of any diameter and length. Subsequent to analysis by Electron Microscopy the number of airborne fibers shall be determined by multiplying the number of fibers, regardless of composition, counted by the PCM NIOSH 7400 Method procedure by a number equal to asbestos fibers counted divided by all fibers counted in the electron microscopy analysis.
9. If electron microscopy is used to arrive at the basis for determining airborne fiber counts in accordance with the above paragraph, and if the average of airborne asbestos fibers in all samples taken exceeds 0.1 f/cc, or if any one sample exceeds 0.2 f/cc, then the cost of such analysis will be born by the Contractor, at no additional cost to the Owner.
10. The Owner's Representative will secure at least the following air samples to establish a base line before start of work involving large enclosures:

Location Sampled	**Number of Samples**	**Analysis Method**	**Detection Limit f/cc**	**Minimum Volume Liters**	**Rate LPM**
Each Work Area	1	PCM	0.01	1,900	2-16
Outside Each Work Area	1-3	PCM	0.01	1,900	2-16

11. Base Line is an action level expressed in f/cc, which is ten percent greater than the largest of the following:
    a. Average of the samples collected on cellulose ester filters outside each work area.
    b. Average of the samples collected on cellulose ester filters outside the building.
    c. 0.01 fibers per cubic centimeter.
12. Daily: From start of work of Paragraph "Temporary Enclosure" through the work of Paragraph "Project Decontamination," the Owner may be taking the following samples on a daily basis. The location of each air sample will be determined by the Owner's Representative.
    a. Baseline
    b. Work Area
13. For larger enclosures samples will be collected on 25 mm cassettes with the following filter medial:
    PCM: 0.8 micrometer mixed cellulose ester.

Location Sampled	Number of Samples	Analysis Method	Detection Limit f/cc	Minimum Volume Liters	Rate LPM
Each Work Area	2	PCM	0.01	1,900 as required by conditions	2-16
Outside Each Work Area Critical Barrier	1	PCM	0.01	1,900	2-16
Clean Room	1	PCM	0.01	1,900	2-16
Equip Decon	1	PCM	0.01	1,900	2-16

14. Additional samples may be taken at the Owner or the Owner's Representative discretion. If airborne fiber counts exceed allowed limits, additional samples will be taken as necessary to monitor fiber levels.
15. The services of a testing laboratory will be employed by the Owner to perform laboratory analysis of the air samples. Samples will be sent daily so that verbal reports on air samples can be obtained in a timely manner. A complete record, certified by the testing laboratory, of all air monitoring tests and results will be furnished to the Owner's Representative, the Owner and the Contractor.
16. Air samples may be analyzed on site by the Owner's Representative, if they are to be analyzed by the NIOSH 7400 Method.
17. Cellulose ester filters will be analyzed using the PCM NIOSH 7400 Method. Thus analysis will be carried out at a laboratory located off the job site.
18. At the completion of the work in occupied areas and prior to the dismantling of the isolation system, final air clearance will be conducted by Owner's Representative.
19. Decontamination of the work area will be considered complete when all samples indicate fiber levels are less than 0.0l f/cc of air as analyzed by PCM NIOSH 7400 Method or an average of less than 70 structures per square millimeter of filter area as analyzed by TEM; Level II AHERA Method.
20. The Contractor may conduct his own air monitoring and laboratory testing. If he elects to do this the cost of such air monitoring and laboratory testing shall be included in the Contract Sum.

P. Equipment Removal Procedures
1. Clean all external surfaces of contaminated waste containers and equipment thoroughly by wet sponging or HEPA vacuuming before moving such items into the equipment decontamination enclosure system washroom for final cleaning and removal to uncontaminated areas. Ensure that personnel do not leave the work areas through the equipment decontamination enclosure system.

Q. Disposal Activities
1. It is the responsibility of the Contractor to comply with current federal, state and local regulations concerning the waste handling, transportation, and disposal of asbestos-containing material (ACM) and accompanying solvents or residues.
2. The Contractor will document actual disposal of the waste at the designated landfill by completing Disposal Certificate or submitting proof of landfill receipt.

1.2 PRODUCTS

A. Materials
1. All Contractor's equipment delivered to the site shall be free of asbestos contamination.
2. Store all materials subject to damage off the ground, away from wet or damp surfaces, and under cover sufficient to prevent damage or contamination.
3. Damaged or deteriorating materials shall not be used and shall be removed from the premises. Materials that become contaminated shall be disposed of in accordance with applicable regulations.
4. Polyethylene flame retardant sheet of 6-mil thickness shall be used unless otherwise specified. Polyethylene sheeting shall be sized to minimize the frequency of joints. Polyethylene sheeting must satisfy the National Fire Prevention Association Standard 701, "Small Scale Fire Test for Flame Resistant Textile and Film."
5. Adhesive tape shall be capable of sealing joints of adjacent sheets of polyethylene and for use in attachment of polyethylene sheet to finished or unfinished surfaces of similar materials and shall be capable of adhering under dry and wet conditions, including use of amended water. Contractor shall use adhesive tape compatible with finished surfaces.

6. Protective devices such as, but not limited to, disposable clothing, respirators, gloves, hard hats, etc. shall be used.
7. Wetting agent shall be a mixture of 50/50 polyoxyethylene ether and polyglycol ester or equivalent commercial product.
8. Encapsulant materials shall be the bridging and penetrating type and conform with the following characteristics:
   a. Encapsulants shall not be solvent-based or utilize a hydrocarbon in the liquid in which the solid parts of the encapsulant are suspended.
   b. Encapsulant shall not be flammable.
9. A non-hardening lagging sealer for enclosing and sealing raw exposed edges and surfaces of asbestos-containing materials.
10. Pre-mixed or job mixed insulating plaster manufactured for use on plumbing equipment shall be used when repairing damaged thermal insulation material.
11. Non-woven fibrous glass mat and open weave glass fiber mat cloth for repair of thermal systems insulation.
12. Fire retardant sealant shall prevent fire, smoke, water and toxic fumes from penetrating through sealants. Sealant shall have a flame spread, smoke and fuel contribution of zero, and shall be ASTM and Underwriter's Laboratory (UL) rated for three hours for standard method of fire test for fire stop systems.

B. Tools And Equipment
1. Provide suitable tools for repair and encapsulation of asbestos-containing materials and for removal of asbestos-containing materials that are beyond repair. Wire brushes shall not be used as a means of removing or cleaning asbestos-containing materials from surfaces, if they are used as the surface is being sprayed with water or amended water.
2. Provide sufficient number of HEPA-filtered vacuum cleaners equipped with pick-up adapters, steel floor wands, crevice tools, and carpet tools.
3. Airless sprayers capable of spraying amended water shall be provided in sufficient number to allow continuous uninterrupted work.
4. Asbestos filtration devices shall utilize high efficiency particulate air (HEPA) filtration systems.
5. Transportation equipment, as required, shall be suitable for loading, temporary storage, and unloading of contaminated waste without exposure to persons or property, and shall be quiet in motion if used within the building.

1.3 EXECUTION

A. Safety Procedures For Power And Lighting
1. The use of wet methods for removal, repair, encapsulation or cleaning procedures increases the potential for electrical shock when working around electrical panels, conduit, light fixtures, alarm systems, junction boxes, transformers, etc. In coordination with the Owner, de-energize as much electrical equipment as possible to prevent electrical shock to employees performing the work. The Contractor shall use the following precautions:
   a. Use non-conductive tools and vacuum attachments.
   b. Utilize "hot line" covers over energized cables and power lines when possible.
   c. Ensure all electrical equipment in use is properly grounded before the job starts. Check outlets, wiring, extension cords and power pickups.
   d. Avoid stringing wiring across floors. Elevate wiring if possible.
   e. Ensure electrical outlets are tightly sealed and taped to avoid water spray.
   f. Determine operating voltages of equipment and lines before working on or near energized parts.
   g. Energized parts must be insulated or guarded from employee contact and other conductive objects. Extension cords must be three-wire type and connected to a Ground Fault Interrupter (GFI) circuit.
   h. Lock or secure de-energized circuits at panel and post warning signs.

i. Seal heating vents with two layers of polyethylene sheeting prior to the start of work. The Contractor shall repair any damage caused by Contractor's operations to duct work, grilles, dampers, louvers or HVAC equipment at the completion of the work at Contractor's expense. Coordinate all lock out and or de-energizing with Owner.

B. Temporary Facilities

1. Use qualified tradesmen for installation of temporary services and facilities. Locate temporary services and facilities where they will serve the entire project adequately and result in minimum interference with the performance of the work and operations of the building. Coordinate all installations and shut downs with building owner.
2. Relocate, modify and extend services and facilities as required during the course of work so as to accommodate the entire work of the project.
3. Provide new or used materials and equipment that are undamaged and in serviceable condition. Provide only materials and equipment that are recognized as being suitable for the intended use, by compliance with appropriate standards.
4. During the erection and/or moving of scaffolding, care must be exercised so that the polyethylene floor covering is not damaged.
5. Clean, as necessary, debris from non-slip surfaces.
6. At the completion of abatement work, clean all construction aids within the work area, wrap in one layer of 6-mil polyethylene sheet and seal before removal from the work area.
7. Temporary water service connections to the Owner's water system shall include back flow protection. Valves shall be temperature and pressure rated for operation of the temperatures and pressures encountered.
8. Employ heavy-duty abrasion-resistant hoses with a pressure rating 50 percent greater than the maximum pressure of the water distribution system to provide water into each work area and to each Decontamination Unit. Provide fittings as required to allow for connection to existing wall hydrants or spouts, as well as temporary water heating equipment, branch piping, showers, shut-off nozzles and equipment.
9. Electrical Services shall comply with applicable NEMA, NECA and UL standards and governing regulations for materials and layout of temporary electric service.
10. Provide a weatherproof, grounded temporary electric power service and distribution system of sufficient size, capacity, and power characteristics to accommodate performance of work during the construction period. Install temporary lighting adequate to provide sufficient illumination for safe work and traffic conditions in every area of work.
11. Provide receptacle outlets equipped with ground fault circuit interrupters, reset button and pilot light, for plug-in connection of power tools and equipment.
12. Use only grounded extension cords; use "hard-service" cords where exposed to abrasion and traffic. Use single lengths or use waterproof connectors to connect separate lengths of electric cords, if single lengths will not reach areas of work. All cords shall be elevated off the floor inside the containment area.
13. Temporary wiring in the work area shall be type UL non-metallic sheathed cable located overhead and exposed for surveillance. Do not wire temporary lighting with plain, exposed (insulated) electrical conductors. Provide liquid tight enclosures or boxes for wiring devices.
14. Provide Type "A" fire extinguishers for temporary offices and similar spaces where there is minimal danger of electrical or grease-oil-flammable liquid fires. In other locations provide type "ABC" dry chemical extinguishers, or a combination of several extinguishers of NFPA recommended types for the exposures in each case.
15. Use of the Owner's existing toilet facilities, as indicated, will be permitted, so long as these facilities are properly cleaned and maintained in a condition acceptable to the Owner. At substantial completion, restore these facilities to the condition prevalent at the time of initial use. All provisions of these specifications regarding leaving the work area must be met.
16. When mini-enclosures area being used all of the requirements above will be enforced by the Owner's Representative. The construction and set-up of the mini-enclosures may be done by the Abatement Contractor.

C. Pressure Differential System

1. Before start of work Contractor shall submit design of pressure differential system to the Owner's Representative for review. Do not begin work until system has been approved by Owner's Representative. Include in the submittal the following:
   a. Number of pressure differential machines required and the calculations necessary to determine the number of machines.
   b. Description of projected air-flow within work area and methods required to provide adequate air flow in all portions of the work area.
2. If the enclosure is not a mini-enclosure, the Contractor must supply the required number of asbestos air filtration units to the site in accordance with these specifications. Each unit shall include the following:
   a. Cabinet constructed of steel or other durable materials able to withstand damage from rough handling and transportation. The width of the cabinet should be less than 30 inches to fit through standard-size doorways. Cabinet shall be factory sealed to prevent asbestos-containing dust from being released during use, transport, or maintenance. Access to and replacement of all air filters shall be from intake end. Unit shall be mounted on casters or wheels.
   b. Rate capacity of fan according to useable air-moving capacity under actual operating conditions. Use centrifugal-type fan.
   c. The final filter shall be the HEPA type. The filter media (folded into closely pleated panels) must be completely sealed on all edges with a structurally rigid frame.
   d. A continuous rubber gasket shall be located between the filter and the filter housing to form a tight seal.
   e. Provide HEPA Units that are individually tested and certified on site by an independent testing agency to have an efficiency of not less than 99.97 percent when challenged with 0.3 m dioctylphthlaate (DOP) particles when tested in accordance with Military Standard Number 2182 and Army Instruction Manual 136-300-175A. Provide filters that bear a UL586 label to indicate ability to perform under specified conditions.
   f. Pre-filters, which protect the final filter by removing the larger particles, are required to prolong the operating life of the HEPA filter. Two stages of pre-filtration are required. The first-stage pre-filter shall be a low-efficiency type (e.g., for particles 10 microns and larger). The second-stage (or intermediate) filter shall have a medium efficiency (e.g., effective for particles down to 5 microns). Pre-filters and intermediate filters shall be installed either on or in the intake grid of the unit and held in place with special housings or clamps.
   g. Each unit shall be equipped with a Magnahelic gauge or manometer to measure the pressure drop across filters and indicate when filters have become loaded and need to be changed. A table indicating the useable air-handling capacity for various static pressure readings on the Magnahelic gauge shall be affixed near the gauge for reference, or the Magnahelic reading indicating at what point the filters should be changed, noting Cubic Feet per Minute (CFM) air delivery at that point. Provide units equipped with an elapsed time meter to show the total accumulated hours of operation.
   h. The unit shall have an electrical (or mechanical) lockout to prevent fan from operating without a HEPA filter. Units shall be equipped with automatic shutdown system to stop fan in the event of a major rupture in the HEPA filter or blocked air discharge. Warning lights are required to indicate normal operation, too high a pressure drop across the filters (i.e., filter overloading), and too low of a pressure drop (i.e., major rupture in HEPA filter or obstructed discharge).
   i. Electrical components shall be approved by the National Electrical Manufacturers Association (NEMA) and Underwriters' Laboratories (UL). Each unit shall be equipped with overload protection sized for the equipment. The motor, fan, fan housing, and cabinet shall be grounded.
   j. If a mini-enclosure is used the air filtration unit may be a HEPA filtered vacuum with a flow rate of at least 100 cubic feet per minute (CFM).
3. Provide a fully operational pressure differential system within the work area maintaining continuously a pressure differential across work area enclosures of 0.02 inches of water for glove

bag operations and mini-containments**.** Demonstrate to the Owner's Representative the pressure differential by use of pressure differential meter or a manometer, before disturbance of any asbestos-containing materials. In the case of a mini-enclosure visual evidence of pressure differential through the use of a smoke generation tube shall be sufficient as in paragraph C.13 of this section.

4. Continuously monitor and record the pressure differential between the work area and the building outside of the work area.
5. Provide fully operational negative pressure systems supplying a minimum of one air change every ten minutes (six changes per hour), less in the instance of a mini-enclosure. Determine the volume in cubic feet of the work area by multiplying floor area by ceiling height. Determine total ventilation requirement in cubic feet per minute (cfm) for the work area by dividing this volume by the air change rate.
6. Ventilation Required (CFM) = Volume of work area (cu. ft.)/10 min.
7. Determine number of units needed to achieve ten-minute change rate by dividing the ventilation requirement (CFM) above capacity of exhaust unit(s) used. Capacity of a unit for purposes of this section is the capacity in cubic feet per minute with fully loaded filters (pressure differential which causes loaded filter warning light to come on) in the machines labeled operating characteristics.
8. Add one additional unit as a backup in case of equipment failure or machine shutdown for filter changing.
9. Locate exhaust unit(s) so that makeup air enters work area primarily through decontamination facilities and traverses work area as much as possible. This may be accomplished by positioning the unit(s) at a maximum distance from the worker access opening or other makeup air sources.
10. Vent to outside of building, unless authorized in writing by the Owner's Representative.
11. Each unit shall be serviced by a dedicated minimum 115v-20A circuit with overload device tied into an existing building electrical panel which has sufficient spare capacity to accommodate the load of all pressure differential units connected. Dedication of an existing circuit may be accomplished by shutting down existing loads on the circuit.
12. Test pressure differential system before any asbestos-containing material is wetted or removed. After the work area has been prepared, the decontamination facility set up, and the exhaust unit(s) installed, start the unit(s) (one at a time). Demonstrate operation and testing of pressure differential system to the Owner's Representative.
13. Demonstrate of operations of the pressure differential system to the Owner's Representative will include, but not be limited to, the following:
    a. Plastic barriers and sheeting move lightly in toward work area.
    b. Curtain of decontamination units move lightly in toward work area.
    c. There is a noticeable movement of air through the decontamination unit. Use stroke tube to demonstrate air movement from clean room, and from equipment room to work area.
    d. Use smoke tubes to demonstrate a positive motion of air across all area in which work is to be performed.
    e. Use a differential pressure meter or manometer to demonstrate a pressure difference of at least 0.02 inches (as allowed) of water across <u>every</u> barrier separating the work area from the balance of the building or outside. This is not required in the case of a mini enclosure.
14. Start exhaust units before beginning work (before any asbestos-containing material is disturbed). After abatement work has begun, run units continuously to maintain a constant negative pressure until decontamination of the work area is complete. Do not turn off units at the end of the work shift or when abatement operations temporarily stop.
15. Do not shut down pressure differential system during encapsulating procedures, unless authorized by the Owner's Representative in writing. Start abatement work at a location farthest from the exhaust units and proceed toward them. If an electric power failure occurs, immediately stop all abatement work and do not resume until power is restored and exhaust units are operating again.
16. At completion of abatement work, allow exhaust units to run as specified to remove airborne fibers that may have been generated during abatement work and cleanup and to purge the work area with clean makeup air. The units may be required to run for a longer time after decontamination, if

dry or only partially wetted asbestos material was encountered during any abatement work. In the case of a mini-enclosure the vacuum may be removed and the entrance sealed following encapsulation until the clearance sample is collected.

17. Prior to final air test, remove pre-filter and wipe out inside lip of negative air machine.
18. When a final inspection and the results of final air tests indicate that the area has been decontaminated, exhaust units may be removed from the work area. Before removal from the work area, remove and properly dispose of pre-filter, and seal Intake to the machine with 6-mil polyethylene to prevent environmental contamination from the filters.

D. Work Area Preparation

1. The work area is the location where asbestos-abatement work occurs. It is a variable of the extent of work of the contract. It may be a portion of a room, a single room, or a complex of rooms. A "work area" is considered contaminated during the work, and must be isolated from the balance of the building, and decontaminated at the completion of the asbestos-control work.
2. Pre-clean fixed objects, walls and floor surfaces within the proposed work areas using HEPA filtered vacuum equipment and wet cleaning methods as appropriate.
3. Seal all openings, supply and exhaust vents, and convectors within ten feet of the work area with 6-mil polyethylene sheeting secured and completely sealed with plastic adhesion tape.
4. Contact fire control agencies to review procedures prior to start of work.
5. Provide flame resistant polyethylene sheeting that conforms to requirements set forth by the National Fire Protection Association Standard 701, Small Scale Fire Test for Flame-resistant Textiles and Films. Provide largest size possible to minimize seams, four- or six- mils thick, frosted or black.
6. Provide spray adhesive in aerosol cans which is specifically formulated to stick tenaciously to sheet polyethylene and supporting surface.
7. Completely isolate the work area from other parts of the building so as to prevent asbestos-containing dust or debris from passing beyond the isolated area. Should the area beyond the work area(s) become contaminated with asbestos-containing dust or debris as a consequence of the work, clean those areas in accordance with the procedures indicated in Paragraph "Decontamination Procedures." All such required cleaning or decontamination shall be performed at no additional cost to the Owner.
8. Place all tools (i.e., scaffolding, staging) necessary for the work in the area to be isolated prior to erection of plastic sheeting temporary enclosure.
9. Disable ventilation systems or any other system bringing air into or out of the work area. Disable system by disconnecting wires, removing circuit breakers, by lockable switch or other positive means that will prevent accidental premature restarting of equipment.
10. Remove and dispose of all electrical and mechanical items, such as lighting fixtures, clocks, diffusers, registers, escutcheon plates, etc., which cover any part of the surface on which work is to be performed.
11. All general construction items such as cabinets, casework, doors and window trim, moldings, ceilings, trim, etc., which cover the surface of the work as required to prevent interference with the work. To be performed by the Owner: clean, decontaminate and reinstall all such materials, upon completion of all removal work with materials, finishes, and workmanship to match existing installations before start of work.
12. Permit Access to the work area only through the Decontamination Unit. All other means of access shall be closed off and sealed and warning signs displayed on the clean side of the sealed access.
13. Provide Warning Signs at each visual and physical barriers reading as follows in both English and Spanish:

Legend	Notation
KEEP OUT	3" Sans Serif Gothic or Block
BEYOND THIS POINT	1" Sans Serif Gothic or Block
ASBESTOS ABATEMENT WORK	1" Sans Serif Gothic or Block

IN PROGRESS BREATHING ASBESTOS DUST MAY BE HAZARDOUS TO YOUR HEALTH	1" Sans Serif Gothic or Block 14 Point Gothic

14. Alternate methods of containing the work area may be submitted to the Owner's Representative for approval. Do not proceed with any such method(s) without prior written approval of the Owner's Representative.
15. Individually seal all ventilation openings (supply and exhaust), lighting fixtures, clocks, doorways, windows, convectors and speakers, and other openings into the work area with plastic adhesion tape alone or with polyethylene sheeting at least 4-mil in thickness, taped securely in place with plastic adhesion tape. Maintain seal until all work including Project Decontamination is completed. Take care in sealing off lighting fixtures to avoid melting or burning of sheeting.
16. Provide sheet plastic barriers at least 6-mil in thickness as required to completely seal openings from the work area into adjacent areas. Seal the perimeter of all sheet plastic barriers with plastic adhesion tape or spray cement.
17. Where applicable, construct framing of the containment out of fire treated wood or aluminum studs. Mini-enclosure frames may be constructed of Polyvinyl Chloride (PVC) tubing.
18. Cover all walls in work area extending to the underside of the ceiling grid system with one layer of polyethylene sheeting, at least 6-mil in thickness, mechanically supported and sealed with plastic adhesion tape or spray-glue in the same manner as "Critical Barrier" sheet plastic barriers. Tape all joints with plastic adhesion tape. Contractor shall be responsible for repair of damaged wall finishes.
19. Cover floor with two layers of 6-mil polyethylene sheeting (exclude for floor tile and adhesive).
20. Provide Pressure Differential System per Paragraph “Pressure Differential System.”
21. If the enclosure barrier is breached in any manner that could allow the passage of asbestos debris or airborne fibers, then add the affected area to the work area, enclose it as required by this section of the specification and decontaminate it as described in Paragraph “Decontamination Procedures.”
22. Establishing a Mini-Containment area:
    a. Establish work area so that unauthorized entry is prevented; Construct a two-compartment fire treated wood frame around work area; install one layer 6-mil polyethylene sheeting to structural members and two layers 6 mil polyethylene sheeting to the floor. Exception: no floor required if mini-containment is being constructed to perform a floor tile activity. Seal all edges to wall, ceiling, and floor surfaces with duct tape. Install viewing inspection windows, where feasible.
    b. Seal all penetrations with duct tape such as pipes, electrical conduit, or ducts contained within the mini-containment.
    c. Install triple 6-mil polyethylene flaps at both doorways. Place portable sprayer with clean water, disposable towels, and pre-labeled disposal bag in air lock.
    d. Install appropriate signs on outside of mini-containment area.
    e. Install HEPA vacuum; extend hose into mini-containment area for general vacuuming, negative air, and cleaning of disposal suit.
    f. Accumulate all loose materials for disposal. Place in approved container. Apply appropriate labels. Adequately wet clean all wall, floor, tool and equipment surfaces.
    g. Abatement worker must wear two disposable suits. Remove outer suit in work area and place in a plastic bag. Enter air lock.
    h. In air lock, wet wipe respirator and wash hands with clean water. Remove respirator and place in a clean plastic bag. Proceed to remote shower unit where inner suit may be removed.

E. Worker Protection
1. This section describes the equipment and procedures required for protecting workers against asbestos contamination and other work place hazards except for respiratory protection.
2. Respiratory Protection is specified in Paragraph “Respiratory Protection.”

3. Train in accordance with EPA's Model Accreditation Plan, 40 CFR 763 - Asbestos, all workers in the dangers inherent in handling asbestos and breathing asbestos dust and in proper work procedures and personal and area protective measures. Include but do not limit the topics covered in the course to the following:
   a. Methods of recognizing asbestos.
   b. Health effects associated with asbestos.
   c. Relationship between smoking and asbestos in producing lung cancer.
   d. Nature of operations that could result in exposure to asbestos.
4. Importance of and instruction in the use of necessary protective controls, practices and procedures to minimize exposure including:

   Engineering controls
   Work practices
   Respirators
   Housekeeping procedures
   Hygiene facilities
   Protective clothing
   Decontamination procedures
   Emergency procedures
   Waste disposal procedures
   Appropriate work practices for the work
   Requirements of medical surveillance program
   Review of OSHA 29 CFR 1926.1101(k)(9)(viii)(G) - Asbestos
   Pressure differential systems
   Work practices including hands on or on job training
   Personal decontamination procedures
   Air monitoring, personal and area

5. Provide medical examinations for all workers who may encounter an airborne fiber level of 0.1 f/cc or greater for an 8 hour time weighted average. In the absence of specific airborne fiber data, provide medical examination for all workers who will enter the work area for any reason. Examination shall, at minimum, meet OSHA requirements as set forth in 29 CFR 1926.1101(k)(9)(viii)(G) - Asbestos. In addition, provide an evaluation of the individual's ability to work in environments capable of producing heat stress in the worker.
6. Before start of work Contractor shall submit the following to the Owner's Representative for review. Do not start work until receipt of Owner's Representative.
   a. An original signed copy of the Certificate of Worker's Acknowledgement found at the end of this specification, for each worker who is to be at the job site or enter the work area.
   b. Courses outline or name of institution providing the worker training course.
   c. Report from medical examination conducted within last 12 months as part of compliance with OSHA medical surveillance requirements for each worker who is to enter the work area.
7. Provide disposable full-body coveralls and disposable head covers, and require that they be worn by all workers in the work area. Provide a sufficient number for all required changes, for all workers in the work area.
8. Provide work boots with non-skid soles, and where required by OSHA, foot protectives, for all workers. Provide boots at no cost to workers. Paint uppers of all boots red with water proof enamel. Do not allow boots to be removed from the work area for any reason, after being contaminated with asbestos-containing material. Dispose of boots as asbestos contaminated waste at the end of the work.
9. Provide head protectives (hard hats) as required by OSHA for all workers, and provide four spares for use by Owner's Representative, and Owner. Label hats with same warning labels as used on disposal bags. Require hard hats to be worn at all times that work is in progress that may potentially cause head injury. Provide hard hats with plastic strap type suspension. Require hats

to remain in the work area throughout the work. Thoroughly clean, decontaminate and bag hats before removing them from work area at the end of the work.

10. Provide eye protectives (goggles) as required by OSHA for all workers involved in scraping, spraying, or any other activity which may potentially cause eye injury.
11. Provide work gloves to all workers and require that they be worn at all times in the work area. Do not remove gloves from work area. Dispose of gloves as asbestos contaminated waste at the end of the work.
12. Respirators, disposable coveralls, head covers, and footwear covers shall be provided by the contractor for the Owner, Owner's Representative, and other authorized representatives who may inspect the job site.
13. Provide worker protection as required by the most stringent OSHA and/or EPA standards applicable to the work. The following procedures are minimums to be adhered to regardless of fiber count in the work area.
14. Each time work is entered, remove <u>all</u> street clothes in the changing room of the Personnel Decontamination Unit and put on new disposable coverall, new head cover, and a clean respirator. Proceed through shower room to equipment room and put on work boots.
15. In the event a mini-enclosure is used refer to Paragraph "Work Area Preparation" for personal decontamination procedures.

F. Respiratory Protection

1. Instruct and train each worker involved in asbestos abatement or maintenance and repair of friable asbestos-containing materials in proper respiratory use and require that each worker always wear a respirator, properly fitted on the face in the work area from the start of any operation which may cause airborne asbestos fibers until the work area is completely decontaminated. Use respiratory protection appropriate for the fiber level encountered in the work place or as required for other toxic or oxygen-deficient situations encountered.
2. Except to the extent that more stringent requirements are written directly into the Contract Documents, the following regulations and standards have the same force and effect (and are made a part of the Contract Documents by reference) as if copied directly into the Contract Documents, or as if published copies were bound herewith. Where there is a conflict in requirements set forth in these regulations and standards meet the more stringent requirement.
   a. OSHA - U.S. Department of Labor Occupational Safety and Health Administration, Safety and Health Standards 29 CFR 1910, Section 1001 and Section 1910.134.29 CFR 1926.
   b. ANSI - American National Standard Practices for Respiratory Protection. ANSI Z88.2-1980.
   c. NIOSH - National Institute for Occupational Safety and Health.
   d. MSHA - Mine Safety and Health Administration.

G. Type Of Respiratory Protection Required

1. Provide Respiratory Protection as indicated in paragraph below. Where paragraph below does not apply, determine the proper level of protection by dividing the expected or actual airborne fiber count in the work area by the "protection factors" given below. The level of respiratory protection which supplies an airborne fiber level inside the respirator, at the breathing zone of the wearer, at or below 0.01 fibers/cubic centimeter is the minimum level of protection allowed.
2. Eight-hour Time Weighted Average (TWA) of asbestos fibers to which any worker may be exposed shall not exceed 0.1 fibers/cubic centimeter.
3. For purposes of this section fibers are defined as all fibers regardless of composition as counted in the OSHA Reference Method (ORM), NIOSH P&CAM 239 or 7400 procedure, or asbestos fibers of any size as counted using either a scanning or transmission electron microscope.
4. Require that respiratory protection be used at all times that there is any possibility of disturbance of asbestos-containing materials whether intentional or accidental.
5. Require that a respirator be worn by anyone in a work area at all tunes, regardless of activity, during a period that starts with any operation which could cause airborne fibers until the area has been cleared for re-occupancy.

H. Respiratory Protection Factor

Respirator Type	Protection Factor
Air purifying: Negative pressure respirator High efficiency filter Half facepiece	10
Air purifying: Negative pressure respirator High efficiency filter Full facepiece	50
Powered-air purifying (PAPR): Positive pressure respirator High efficiency filter Half or Full facepiece	100
Type C supplied air: Positive pressure respirator continuous-flow Half or full facepiece	100
Type C supplied air: Positive pressure respirator pressure demand Full facepiece	1000
Type C supplied air: Positive pressure respirator pressure demand Full facepiece Equipped with an auxiliary positive pressure Self-contained breathing apparatus (SCBA)	over 1000
Self-contained breathing apparatus (SCBA): Positive Pressure respirator Pressure demand Full facepiece	over 1000

I. Air Purifying Respirator

1. Provide half face or full face type respirators. Equip full-face respirators with a nose cup or other anti-fogging device as would be appropriate for use in air temperatures less than 32 degrees Fahrenheit.
2. Provide, at a minimum, HEPA type filters labeled with NIOSH and MSHA certification for "Radionuclides, Radon Daughters, Dust, Fumes, Mists including Asbestos-Containing Dusts and Mists" and color coded in accordance with ANSI Z228.2 (1980). In addition, a chemical cartridge section may be added, if required, for solvents, etc., in use. In this case, provide cartridges that have each section of the combination canister labeled with the appropriate color code and NIOSH/MSHA Certification.
3. Supply with a sufficient quantity of respirator filters approved for asbestos, so that workers can change filters during the work day. Require that respirators be wet-rinsed, and filters discarded, each time a worker leaves the work area. Require that new filters be installed each time a worker re-enters the work area. Store respirators and filters at the job site in the changing room and protect totally from exposure to asbestos prior to their use. Do not use single use, disposable or quarterface respirators.

J. Powered Air Purifying Respirator (PAPR)
   1. Provide full-facepiece type respirators. Provide nose-cups for full-facepiece respirators. Provide, at a minimum, HEPA type cartridges approved by NIOSH/MSHA and certified for use in atmospheres containing asbestos dusts.
   2. Provide, at a minimum, one extra battery pack for each respirator so that one can be charging while one is in use.
   3. Provide non-cloth belts capable of being decontaminated in shower.
   4. Supply with a sufficient quantity of high efficiency respirator filters approved for asbestos so that workers can change filters at any time that flow through the face piece decreases to the level at which the manufacturer recommends filter replacement. Require that regardless of flow, filter cartridges be replaced after 40 hours of use. Require that HEPA elements in filter cartridges be protected from wetting during showering. Require entire exterior housing of respirator including blower unit, filter cartridges, hoses, battery pack, face mask, belt, and cords to be washed each time a worker leaves the work area. Caution should be used to avoid shorting battery pack during washing.

K. Required Respiratory Protection
   1. Regardless of airborne fiber levels, require the following minimum level of respiratory protection:
      a. Half-face air purifying respirators may be used during set-up of the containment and removal of the material so long as fiber counts inside the respirator do not exceed .01 f/cc fibers per cubic centimeter.

L. Decontamination Units -Three-Stage
   1. Provide a Personnel Decontamination Unit consisting of a serial arrangement of rooms or spaces, Changing Room, Shower Room, Equipment Room adjacent to each full containment area.
   2. Require all persons without exception to pass through this decontamination unit for entry into and exiting from the work area for any purpose. Do not remove equipment or materials through Personnel Decontamination Unit.
   3. Changing (Clean) Room:
      a. Provide a room that is physically and visually separated from the rest of the building for the purpose of changing into protective clothing.
      b. Locate so that access to work area from changing room is through shower room.
      c. Separate changing room from the building by a double-sheeted polyethylene flapped doorway.
      d. Provide sub-panel at changing room to accommodate all removal equipment. Power sub-panel directly from a building electrical panel. Connect all electrical branch circuits in decontamination unit and particularly any pumps in shower room to a ground-fault circuit protection device.
   4. Shower Room:
      a. Provide a completely water tight operational shower to be used for transit by cleanly dressed workers heading for the work area from the changing room, or for showering by workers headed out of the work area after undressing in the equipment room.
      b. Construct room by providing a shower pan and two shower walls in a configuration that will cause water running down walls to drip into pan. Install a freely draining wood floor in shower pan at elevation of top of pan.
      c. Separate this room from rest of building, drying room and airlock with airtight walls fabricated of 6-mil polyethylene.
      d. Provide splash proof entrances to Drying Room and Airlock.
   5. Equipment Room (contaminated area):
      a. Require work equipment, footwear and additional contaminated work clothing to be left here. This is a change and transit area for workers. Separate this room from the work area by a 6-mil polyethylene flap doorway.
      b. Separate this room from the rest of the building, the shower room and work area with air tight walls fabricated of 6-mil polyethylene.

6. Clean Room: Provide Clean Room to isolate the holding room from the building exterior.
7. Load-out Area:
   a. The load-out area is the transfer area from the building to a truck or dumpster.
   b. Wet wipe bags before they are passed through the equipment decon-chamber.
   c. When cleaning is complete pass items into holding room. Close all doorways except the doorway between the holding room and the Clean Room.
   d. Workers from the area outside the containment area enter holding area and remove decontaminated equipment and/or containers for disposal.
   e. Require these workers to wear full protective clothing and appropriate respiratory protection.
   f. At no time is a worker from an uncontaminated area to enter the enclosure when a removal worker is inside.
   g. Post an approximately 20 inch x 14 inch manufactured caution sign at each entrance to the work area displaying the following legend with letter sizes and styles of a visibility required by OSHA 29 CFR 1926.1101(k)(9)(viii)(J) - Asbestos.

LEGEND
DANGER

ASBESTOS

CANCER AND LUNG DISEASE HAZARD
RESPIRATORS AND PROTECTIVE CLOTHING ARE REQUIRED
IN THIS AREA

   h. Provide spacing between respective lines at least equal to the height of the respective upper line.
   i. Additional Signage: Shall also be posted in accordance with OSHA 29 CFR 1926.1101(k)(9)(viii)(J) - Asbestos

DANGER
ASBESTOS
CANCER AND LUNG DISEASE HAZARD

AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA
DANGER
ASBESTOS
CANCER AND LUNG HAZARD
KEEP OUT

   j. Post an approximately 10 inch by 14 inch manufactured sign at each entrance to each work area displaying the following legend with letter sizes and styles of a visibility at least equal to the following:

LEGEND	NOTATION
No Food, Beverages or Tobacco Permitted	3/4 inch Block
All Persons Shall Don Protective Clothing (Coverings) Before Entering the Work Area	3/4 inch Block
All Persons Shall Shower Immediately After Leaving Work Area and Before Entering the Changing Area	3/4 inch Block

M. Decontamination Procedures

1. Contractor shall require all workers and visitors to adhere to the following personal decontamination procedures whenever they leave the work area:

   a. Require that all workers use the following decontamination procedure as a minimum requirement whenever leaving the work area.
   b. When exiting area, remove disposable coveralls, disposable head covers, and disposable footwear covers or boots in the Equipment Room.
   c. Still wearing respirators, proceed to showers. Showering is mandatory. Care must be taken to follow reasonable procedures in removing the respirator to avoid asbestos fibers while showering. The following procedure is required as a minimum:
      1) Thoroughly wet body including hair and face. If using a PAPR, hold blower unit above head to keep canisters dry.
      2) With respirator still in place thoroughly wash body, hair, respirator face piece, and all parts of the respirator except the blower unit and battery pack on a PAPR. Pay particular attention to seal between face and respirator and under straps.
      3) Take a deep breath, hold it and/or exhale slowly, completely wet hair, face, and respirator. While still holding breath, remove respirator and hold it away from face before starting to breathe.
      4) Carefully wash face-piece of respirator inside and out.
   d. If using PAPR, shut down in the following sequence, first cap inlets to filter cartridges, then turn off blower unit (this sequence will help keep debris which has collected on the inlet side of filter from dislodging and contaminating the outside of the unit). Thoroughly wash blower unit and hoses. Carefully wash battery pack with wet rag. Be extremely cautious of getting water in battery pack as this will short out and destroy battery.
      1) Shower completely with soap and water.
      2) Rinse thoroughly.
      3) Rinse shower room walls and floor prior to exit.
      4) Proceed from shower to changing room and change into street clothes or into new disposable work items.
   e. Require that all workers use the following decontamination procedure as a minimum requirement whenever leaving the work area with a half or full face cartridge type respirator:
      1) When exiting area, remove disposable coveralls, disposable headcovers, and disposable footwear covers or boots in the equipment room.
      2) Still wearing respirators, proceed to showers. Showering is mandatory. Care must be taken to follow reasonable procedures in removing the respirator and filters to avoid asbestos fibers while showering. The following procedure is required as a minimum:
      3) Thoroughly wet body from neck down.
      4) Wet hair as thoroughly as possible without wetting the respirator filter if using an air purifying type respirator.
      5) Take a deep breath, hold it and/or exhale slowly, complete wetting of hair, thoroughly wetting face, respirator and filter (air purifying respirator). While still holding breath, remove respirator and hold it away from face before starting to breath.
      6) Dispose of wet filters from air purifying respirator.
      7) Carefully wash facepiece of respirator inside and out.
      8) Shower completely with soap and water.
      9) Rinse thoroughly.
      10) Rinse shower room walls and floor prior to exit.
      11) Proceed from shower to changing room and change into street clothes or into new disposable work items.

N. Project Decontamination

1. If the asbestos abatement work is on damaged or friable materials, then the building space is deemed contaminated before start of the work and in need of decontamination. In this case, the

procedure includes two cleanings of the primary barrier plastic prior to its removal and two cleanings of the room surfaces to remove any new or existing contamination.

2. Work of this section includes the decontamination of air in the work area which has been, or may have been contaminated by the elevated airborne asbestos fiber levels generated during abatement activities, or which may previously have had elevated fiber levels due to friable materials in the space.
3. Work of this section also includes the cleaning, decontamination, and removal of temporary facilities installed prior to abatement work and decontamination of all surfaces (ceiling, walls, floor) of the work area, and all furniture or equipment in the work area.
4. First Cleaning
   a. Carry out a first cleaning of all surfaces of the work area including items of remaining sheeting, tools, scaffolding and/or staging by use of damp-cleaning and mopping, and/or a HEPA filtered vacuum. (Note: A HEPA vacuum will fail if used with wet material). Do not perform dry dusting or dry sweeping. Use each surface of a cleaning cloth one time only and then dispose as contaminated waste. Continue this cleaning until there is no visible debris from removed materials on plastic sheeting or other surfaces. Upon authorization of Owner's Representative proceed with encapsulation of substrate.
   b. Perform encapsulation of substrate where required at this time. Maintain pressure differential system in operation during encapsulation work. Allow encapsulant to dry before proceeding with removal of Secondary layer of plastic.
5. Second Cleaning
   a. Upon authorization of Owner's Representative, remove all Primary Barrier sheeting and Material Decontamination Unit, if there is one, leaving only the following:
      1) Critical Barrier which forms the sole barrier between the work area and other portions of the building or outside.
      2) Critical Barrier Sheeting over lighting fixtures and clocks, ventilation openings, doorways, convectors, speakers and other openings.
      3) Personnel Decontamination Unit.
      4) Pressure Differential System in continuous operation.
   b. Remove all filters in Air Handling System(s) and dispose of as asbestos-containing waste.
6. Final Cleaning: Carry out a final cleaning of all surfaces in the work in the same manner as the first cleaning immediately after removal of primary plastic. This cleaning is now being applied to existing room surfaces. Take care to avoid water marks or other damage to surfaces.
7. Visual Inspection: Perform a complete visual inspection with Owner's Representative of the entire work area including decontamination unit, all plastic sheeting, seals over ventilation openings, doorways, windows, and other openings; look for debris from any sources, residue on surfaces, dust or other matter. If any such debris, residue, dust or other matter is found repeat cleaning and continue decontamination procedure from that point. When the area is visually clean, complete the certification at the end of this section.
8. Final Air Sampling
   a. After the work area is found to be visually clean, air samples will be taken and analyzed in accordance with the procedures set forth in Paragraph “Powered Air Purifying Respirator (PAPR).
   b. If Release Criteria are not met, repeat cleaning and continue decontamination procedure from that point.
   c. If Release Criteria is met, remove the interior of the decontamination unit leaving in place only the Critical Barriers separating the work area from the rest of the building and the operating negative pressure system.
   d. Any small quantities of residual material found upon removal of the plastic sheeting shall be removed with a HEPA filtered vacuum cleaner and local area protection. If significant quantities, as determined by the Owner's Representative, are found then the entire area affected shall be decontaminated as specified herein for the cleaning.

O. Work Area Clearance
   1. Air Monitoring

a. Visual Inspection is required as a prerequisite of air testing.
b. To determine if the elevated airborne asbestos structure concentration during abatement operations have been reduced to the specified level, the Owner's Representative will secure samples and analyze them according to the following procedures.

2. Aggressive Sampling
   a. All air samples will be taken using aggressive sampling techniques as follows. (There are no standards available for flow rate of leaf blowers or large fans. However, this information is not critical to the success of the procedure).
   b. Before sampling pumps are started, the exhaust from forced-air equipment (leaf blower with at least 1 horsepower electric motor) will be swept against all walls, ceilings, floors, ledges and other surfaces in the room. This procedure will be continued for five minutes per 10,000 cubic feet of room volume.
   c. Air samples will be collected in areas subject to normal air circulation away from room corners, obstructed locations, and sites near windows, doors or vents.
3. Schedule of Air Samples
   a. General: The number and volume of air samples taken and analytical methods used by the Owner's Representative will be in accordance with the following schedule. Sample volumes given may vary depending upon the analytical instruments used. In each homogeneous work area after completion of all cleaning work, samples will be taken and analyzed by either PCM of TEM analysis.
   b. Transmission Electron Microscopy (TEM) Samples:
      1) In each homogeneous work area after completion of all cleaning work, samples will be taken and analyzed by either PCM or TEM analysis as follows:
      2) Samples will be collected on 25 mm cassettes with filter media: TEM - 0.45 micrometer mixed cellulose ester or 0.40 micrometer polycarbonate, with 5.0 micron mixed cellulose ester backing filter.

Location **Sampled**	Number of **Samples**	Detection **Limit** (f/cc)	**Minimum** Volume (Liters)	**Rate** LPM
Each Work Area	5	0.005	1,300	2-10

      3) TEM Analysis_will be performed using the analysis method set forth in the AHERA Regulation 40 CFR Part 763 Appendix A.
      4) Asbestos Structures referred to in this Section include asbestos fibers, bundles, clusters, or matrices, as defined by method of analysis.
      5) Decontamination of the work site is complete when all the sample results are below 0.01 fibers per cubic centimeters (f/cc) of air or 70 structures per square millimeter.
   c. Phase Contrast Microscopy (PCM) Samples:
      1) In each homogeneous work area after completion of all cleaning work, samples may be taken and analyzed as follows:
      2) Samples will be analyzed by PCM for clearance in areas where ceiling tile and/or pipe insulation are removed
      3) Samples will be collected on 25 mm cassettes with filter media: PCM - 0.8 micrometer mixed cellulose ester.

Location Sampled	**Number of Samples**	**Detection Limit** (s/cc)	**Minimum Volume** (Liters)	**Rate** LPM
Each Work Area	1-5	0.01	2,400	2-10

      4) PCM Analysis: Fibers on each filter will be measured using the NIOSH 7400 Method entitled "Fibers" published in the NIOSH Manual of Analytical Methods, 3rd Edition, Second Supplement, August 1987.

5) Fibers: Referred to in this section include fibers regardless of composition as counted by the phase contrast microscopy method used
6) Decontamination of the work site is complete when all the sample results are below 0.01 fibers per cubic centimeters (f/cc) of air or 70 structures per square millimeter.

4. Failure of Clearance Sampling: Should results from analysis of final clearance air samples not meet the specified criteria, Contractor will be responsible for the payment of all costs, including Consultant's time for subsequent clearance air sampling. The costs associated with subsequent re-sampling for final clearance shall be deducted from the Contractor's final payment of the contract amount.

P. Removal Of Pipe Insulation

1. The work of this section applied to the removal of asbestos-containing Pipe Insulation.
   a. Place one layer of 6-mil fire retardant polyethylene sheeting directly below the work. The sheet shall be of sufficient size to completely wrap the pipe once it has been removed.
   b. Thoroughly wet the ends of the pipe with amended water and scrape off a minimum of 6 inches of asbestos wrap from both ends of the pipe. Immediately place the wetted material into pre-labeled asbestos disposal bag(s).
   c. Detach the pipe at each scraped end and place the pipe onto one sheet of 6-mil fire retardant polyethylene sheeting. Wrap the pipe with the 6-mil fire retardant polyethylene sheeting. Contractor shall wrap the pipe with a second sheet of 6-mil, fire retardant polyethylene sheeting and label as asbestos-containing material. Dispose of the bag(s) and duct in accordance with the Paragraph "Handling and Disposal of Asbestos Contaminated Waste" of this specification.
   d. Upon clearance from the Owner's Representative, Contractor shall remove the 6-trail, fire retardant polyethylene sheeting from the openings.

Q. Glove Bag Removal

1. The work of this section applies to full containment or glovebag removal.
2. Isolate the area in accordance with Paragraph "Temporary Facilities."
3. Construct a decontamination unit as described in Paragraph "Decontamination Units" and attach to the work area.
4. Set up pressure differential isolation and ventilation of the work area in accordance to Paragraph "Pressure Differential System."
   a. Upon approval of the enclosure by the Owner's Representative, Contractor may proceed to remove the material using the following method.
   b. Thoroughly wet to satisfaction of Owner's Representative, asbestos-containing insulation to be removed prior to stripping and/or tooling to reduce fiber dispersal into the air. Accomplish wetting by a fine spray (mist) of amended water or removal encapsulant. Saturate material sufficiently to wet the substrate without causing excess dripping. Allow time for removal encapsulant to penetrate material thoroughly. If amended water is used, spray material repeatedly during the work process to maintain a continuously wet condition. If a removal encapsulant is used, apply in strict accordance with manufacturer's written instructions. If insulation is covered with canvas, Contractor will wet the exterior covering and slice it with utility knife while saturating the material.
   c. Mist work area continuously with amended water whenever necessary to reduce airborne fiber levels using commercially available "foggers."
   d. Remove saturated asbestos-containing material in small sections from all areas. Do not allow material to dry out. As it is removed, simultaneously pack material while still wet into disposal bags. Twist neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside and move to wash down station adjacent to material decontamination unit.
   e. Evacuate air from disposal bags with a HEPA filtered vacuum cleaner before sealing.
   f. Contractor must always clean area of visible asbestos debris prior to end of shift.
5. These procedures shall be followed to remove pipe insulation elbows:
   a. Install critical barriers to isolate the work site. Install 2 or 3 Stage Decontamination Units.

b. HEPA vacuum the work site.

c. Provide negative air machine in addition to those required, in the vicinity of the work. Arrange so that exhaust is into the work area, oriented in a direction away from the work. Extend a 2-inch diameter flexible non-collapsing duct from the intake end to a point no more than 4'-0" from any scraping or brushing activity.

d. Locate intake of duct so that airflow is horizontally and slightly downward into intake. Replace primary filter on negative air machine at an interval of no greater than 30 minutes. Allow no more than one scraping or brushing activity per negative air machine.

e. Check pipe where the work will be performed. Wrap damaged (broken lagging, hanging, etc.), pipe in 6 mil plastic and "candy-stripe" with duct tape. Place one layer of duct tape around undamaged pipe at each end where the glovebag will be attached.

f. Place necessary tools into pouch located inside glovebag. This will usually include: bone saw, utility knife, rags, scrub brush, wire cutters, tin snips and pre-wetted cloth.

g. Place one strip of plastic adhesion tape along the edge of the open top slit of glove bag for reinforcement.

h. Place the glove bag around section of pipe to be worked on and staple top together through reinforcing tape. Next, tape the ends of glovebag to pipe itself, where previously covered with plastic or tape.

i. Use smoke tube and aspirator bulb to test seal. Place tube into water sleeve (two-inch opening to glovebag) squeezing bulb and filling bag with visible smoke. Remove smoke tube and twist water sleeve closed. While holding the water sleeve tightly, gently squeeze glovebag and by using a flashlight, look for smoke leaking out, (especially at the top and ends of the glovebag). If leaks are found, tape closed using plastic adhesion tape and re-test.

j. Insert wand from garden sprayer through water sleeve. Plastic adhesion tape water sleeve tightly around the wand to prevent leakage.

k. One person places his hands into the long-sleeved gloves while the second person directs garden sprayer at the work.

l. Use bone saw, if required, to cut insulation at each end of the section to be removed. A bone saw is a serrated heavy gauge wire with ring-type handles at each end. Throughout this process, spray amended water or removal encapsulant on the cutting area to keep dust to a minimum.

m. Remove insulation using putty knives or other tools. Place pieces in bottom of bag without dropping.

n. Rinse all tools with water inside the bag and place back into pouch.

o. Using scrub brush, rags and water, scrub and wipe down the exposed pipe. (Inexpensive horse rub-down mittens work well for this).

p. Remove water wand from water sleeve and attach the small nozzle from HEPA-filtered vacuum. Turn on the vacuum only briefly to collapse the bag.

q. Remove the vacuum nozzle, twist water sleeve closed and seal with plastic adhesion tape.

R. Handling And Disposal Of Asbestos-Containing Waste

1. All waste and asbestos contaminated waste shall be double bagged in pre-labeled 6-mil airtight puncture resistant bags. Labeling shall be in accordance with OSHA and EPA requirements.

   a. Bags of asbestos-containing waste shall be sealed with tape in the work area. Asbestos waste shall not be allowed to dry out prior to sealing bags. While in the work area, bags shall be decontaminated of any bulk debris by wet wiping. Bags shall be pre-labeled in accordance with OSHA and EPA.

   b. The Contractor shall ensure that the sealed bags are transported to the waste disposal site.

2. The Contractor shall establish a manifest system to enable the Owner to report the quantity of asbestos waste being deposited at the landfill. Contractor shall report the quantity of waste in pounds or tons as appropriate. The Contractor must be able to demonstrate custody over all asbestos waste from the time it is removed from the work area until it is deposited at the land fill.

a. Copies of the manifest and any receipts generated during the handling and disposal process shall be provided to Owner's Representative and the Owner.
b. Final manifest and documents must be provided to Owner's Representative and the Owner within two weeks of the removal of the asbestos materials from the site by the waste hauler.

S. Encapsulation Of Asbestos-Containing Materials
1. General provisions of Contract, including General and Supplementary Conditions and Division 01, apply to work of this section.
   a. The work includes the sealing of all piping or vessels from which asbestos-containing insulation has been removed with one coat of a lock down encapsulant.
   b. Where repair work is being performed, the end will be sealed with a minimum of one coat of bridging encapsulant.
2. Submittals
   a. Product Data: Submit manufacturer's technical information including label analysis and application instructions for each material proposed for use.
   b. Installation Instructions: Submit manufacturer's installation instructions with specific project requirements noted.
   c. Performance Warrantee: Submit manufacturer's performance guarantee.
   d. Certification: Submit written approval of entity installing the encapsulant from encapsulant manufacturer.
   e. Material Safety Data Sheet: Submit the Material Safety Data Sheet, or equivalent, in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200) for each surfactant and encapsulating material proposed for use on the work. Include a separate attachment for each sheet indicating the specific worker protective equipment proposed for use with the material indicated.
3. Deliver materials to the job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:
   a. Name or title of material
   b. Manufacturer's stock number and date of manufacture
   c. Manufacturer's name
   d. Thinning Instructions
   e. Application Instructions
4. Deliver materials together with a copy of the OSHA Material Safety Data Sheet for the material.
5. Job Conditions
   a. Apply encapsulating materials only when environmental conditions in the work area are as required by the manufacturer's instructions.
6. Quality Assurance
   a. Installation of Spray-on Encapsulation Materials: Install spray-on materials by a firm and personnel approved by the manufacturer of the primary materials.
   b. Testing: Test material to be encapsulated using methods set forth in ASTM E1494 "Standard Practice for Encapsulants Spray-or-Trowel-Applied for Friable Asbestos-Containing Building Materials."
   c. Performance Warranty: Submit written Performance Warranty, executed by the manufacturer and co-signed by the Contractor, agreeing to repair/replace spray-on work which has cracked, fallen from substrate, or otherwise deteriorated to a condition where it would not perform effectively for its intended purposes due substantially to defective materials or workmanship and not due to abuse by occupants, improper maintenance, non-foreseeable ambient exposures or other causes beyond anticipated conditions and manufacturer's/contractor's control.
   d. Compatibility: Selection and use of encapsulant shall be compatible with replacement materials. Submit manufacturer's data indicating compatibility with replacement materials.
7. Product Selection
   a. Encapsulants: Provide penetrating or bridging type encapsulants specifically designed for application to asbestos-containing material.

b. Standards: Product shall be rated as acceptable for use intended when field tested in accordance with ASTM E1494 "Standard Practice for Encapsulants Spray-or-Trowel-Applied for Friable Asbestos-Containing Building Materials."

c. Fire Safety: Use only materials that have a flame spread index of less than 25, when dry, when tested in accordance with ASTM E84.

8. Manufacturers

a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products, which may be incorporated in the work, include, but are not limited to the following:

1) Penetrating Encapsulants: As currently accepted by the EPA. Refer to most recent EPA approval list.

2) Bridging Encapsulants: As currently accepted by the EPA. Refer to most recent EPA approval list.

9. General

a. Prior to applying any encapsulating material, ensure that application of the sealer will not cause the base material to fail and allow the sealed material to fall of its own weight or separate from the substrate. Should Contractor doubt the ability of the installation to support the sealant, request direction from the Owner's Representative before proceeding with the encapsulating work.

b. Do Not Commence Application of encapsulating materials until all removal work within the work area has been completed.

10. Worker Protection

a. Before beginning work with any material for which a Material Safety Data Sheet has been submitted, provide workers with the required protective equipment. Require that appropriate protective equipment be used at all times.

b. In addition to protective breathing equipment required by OSHA requirements or by this specification, use painting pre-filters on respirators to protect the dust filters when organic solvent based encapsulants are used.

11. Substrate

a. Apply lock down encapsulant to all substrate after all asbestos-containing materials have been removed. Apply in strict accordance with the manufacturer's printed instructions for use of the encapsulation as an asbestos coating. Any deviations from such printed instructions shall be approved by the Owner's Representative in writing prior to commencing work.

b. Apply encapsulant with an airless spray gun with air pressure and nozzle orifice as recommended by the encapsulant manufacturer.

T. Removal Of Floor Tile

1. This section applies to the removal of floor tile.

a. Prior to start of work, wet wipe all surfaces including floor tile to remove any visible dust.

b. Isolate the room by sealing hallway or doors and installing critical barriers on all ducting, windows and other penetrations of the room, in the specified area. Install a splash guard a minimum of 4 feet high on the walls of the room with one layer of 6-mil fire retardant poly.

c. Install a two-stage decontamination configuration contiguous (under certain conditions may be remote) with the work in accordance with Paragraph “Decontamination Units.”

d. Using water or amended water in a Hudson-type sprayer or garden sprayer, lightly mist the area where the material is to be removed. This may take several passes with the hose of the sprayer. Allow time for the water to soak into the material.

e. Immediately place individual tiles in proper asbestos disposal bags. Vacuum collapse the bag, twist the neck of the bag, tape with duct tape, fold the twisted portion over onto itself and tape again. Wipe the outside of the bag with clean damp cloths and place the bag into a second prelabeled disposal bag. Tape shut the second bag.

U. Removal Of Fireproofing

1. The work of this section applies to the removal of all asbestos containing fireproofing including all over-spray that may be located on concrete block, columns, metal deck, beams, fixtures conduit and ducting.
   a. Isolate the floor per Paragraph “Temporary Enclosure.”
   b. Construct a decontamination unit as described in Paragraph “Decontamination Units” and attach to the work area.
   c. Set up pressure differential isolation and ventilation of the work area in accordance to Paragraph “Temporary Pressure Differential and Air Circulation System.”
   d. Upon approval of the enclosure by the Owner's Representative, contractor may proceed to remove the material using the following method.
   e. Pre-clean columns, beams, electrical, mechanical and plumbing systems in the work area using wet wipe and HEPA vacuuming methods. Mask off with flame retardant polyethylene sheeting to protect from contamination during bulk abatement.
   f. Thoroughly wet to satisfaction of Owner's Representative, asbestos-containing fireproofing to be removed prior to stripping and/or tooling to reduce fiber dispersal into the air. Accomplish wetting by a fine spray (mist) of amended water or removal encapsulant. Saturate material sufficiently to wet the substrate without causing excess dripping. Allow time for removal encapsulant to penetrate material thoroughly. If amended water is used, spray material repeatedly during the work process to maintain a continuously wet condition. If a removal encapsulant is used, apply in strict accordance with manufacturer's written instructions.
   g. Mist work area continuously with amended water whenever necessary to reduce airborne fiber levels using commercially available "foggers."
   h. Remove saturated asbestos-containing material in small sections from all areas. Do not allow material to dry out. As it is removed, simultaneously pack material while still wet into disposal bags. Twist neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside and move to wash down station adjacent to material decontamination unit.
   i. Evacuate air from disposal bags with a HEPA filtered vacuum cleaner before sealing.
   j. Provide Pressure Differential Machine in addition to those required in Paragraph “Pressure Differential System,” in the vicinity of the work. Arrange so that exhaust is into the work area, oriented in a direction away from the work. Extend a 12" diameter flexible non-collapsing duct from the intake end to a point no more than 4'-0" from any scraping or brushing activity.
   k. Locate intake of duct so that air flow is horizontally and slightly down-ward into intake. Replace primary filter on pressure differential machine at an interval of no greater that 30 minutes. Allow no more than one scraping or brushing activity per pressure differential machine.

V. Removal Of Wall Plaster: HEPA vacuum work site.
   1. Place two layers of 6-mil flame retardant polyethylene sheeting on the floor adjacent to the wall to be demolished. Pull the wall down in manageable sections onto the polyethylene sheeting. Control dust and fiber release by misting the air and lightly wetting the material with amended water from a Hudson-type sprayer or garden sprayer as it is demolished.
   2. Wrap the first layer of polyethylene sheeting around the material and seal with duct tape. Wrap the second layer of polyethylene sheeting around the bundle and seal with duct tape.
   3. Label and dispose of the entire bundle.
   4. Provide Pressure Differential Machine in addition to those required in Paragraph “Pressure Differential System,” in the vicinity of the work. Arrange so that exhaust is unto the work area, oriented in a direction away from the work. Extend a 12-inch diameter flexible non-collapsing duct from the intake end to a point no more than 4'-0" from any scraping or brushing activity.
   5. Locate intake of duct so that air flow is horizontally and slightly down-ward into intake. Replace primary filter on negative air machine at an interval of no greater that 30 minutes.

W. Clean-Up Of Asbestos-Containing Debris On Ceiling Tile Or Solid Ceiling

1. This section applies to the decontamination of the entire plaster ceiling, removal of existing fiberglass on duct work and removal of all batt insulation covering the existing plaster ceiling.
   a. Isolate the floor per Paragraph "Temporary Facilities."
   b. Construct a decontamination unit as described in Paragraph "Decontamination Units" and attach to the work area. General Contractor will give direction regarding exact location of decontamination unit(s).
   c. Set up pressure differential isolation and ventilation of the work area in accordance to Paragraph "Temporary Pressure Differential and Air Circulation System."
   d. Upon approval of the enclosure by the Owner's Representative, contractor may proceed to remove the material using the following method:
2. These procedures shall be followed to for clean up of asbestos-containing debris on existing plaster ceiling:
   a. This work will be performed prior to the removal of fireproofing. The isolation of the work area is considered essential to the pre-cleaning activities for the total area. Isolate the area in accordance with Paragraph “Temporary Facilities.”
   b. Remove asbestos-containing debris and fiberglass batt and duct insulation and decontaminate the area using the following procedures:
      1) Remove all small debris with the HEPA vacuum.
      2) Gently mist all fiberglass insulation, remove from ducts and ceiling and place into pre-labeled hazardous disposal bags and dispose of in accordance with Paragraph “Disposal of Asbestos Containing Waste Material.”
      3) Exposure of ducting will expose all fireproofing overspray, this material may be removed during the removal of fireproofing from decks and beams.
      4) Pick up all large visible debris on the ceiling or any horizontal surfaces and place in the bottom of a 6-mil polyethylene disposal bag conforming to the requirements of Paragraph “Disposal of Asbestos-Containing Waste.” Place pieces in the bag without dropping and avoiding unnecessary disturbance and release of material.
      5) HEPA vacuum the entire plaster ceiling surface.
   c. Upon completion of the decontamination of the area request a visual inspection of the ceiling and other horizontal surfaces. This area will be considered a portion of work area for the duration of the work and will be included in the final encapsulation of the area.

X. Removal Of Adhesive: This section applies to the removal of all asbestos-containing floor tile and adhesive, sheet vinyl flooring, vinyl floor tile, and baseboard adhesive, etc.
1. Ensure that workers are equipped with proper respiratory protection. In addition to the HEPA cartridges, respirators must also be equipped with organic solvent cartridges.
2. Provide HEPA filtered fan units in the vicinity of the work. Arrange so that units exhaust outside the building. Replace primary filters on HEPA filtered fan units at an interval of no greater than 30 minutes.
3. Apply adhesive removal solvent as recommended by manufacturer after removal of floor tile has been completed.
4. Provide tile adhesive (mastic) remover that meets the following criteria:
   a. Flash Point: 122E or greater.
   b. Special Precautions: No heavy smoke generated if ignited.
   c. Health Effects: Limited to mild skin rash or eye irritation.
   d. Respiratory Protection: MSHA - NIOSH approved Organic vapor cartridges in conjunction with standard HEPA filters.
   e. Petroleum Distillates: None.
   f. Odor: Pine, Citrus or none.

Use of diesel fuel in the removal of tile and baseboard adhesive is strictly prohibited.

5. Remove adhesive in small sections from all areas. Do not allow material to dry out. As adhesive is removed, simultaneously pack rags contaminated with adhesive material into disposal bags. Twist

neck of bags, bend over and seal with minimum three wraps of duct tape. Clean outside of bag and move to material decontamination unit.

6. Upon completion of adhesive removal, thoroughly clean bare substrate of all solvent residue.
7. Place adhesive residue in proper asbestos disposal bags. Vacuum collapse the bag, twist the neck of the bag, tape with duct tape, fold the twisted portion over onto itself and tape again. Wipe the outside of the bag with clean damp cloths and place bag into second prelabeled disposal bag. Tape shut the second bag.

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CERTIFICATE OF WORKER'S ACKNOWLEDGEMENT

PROJECT NAME: _____

PROJECT ADDRESS: _____

CONTRACTOR: _____

WORKING WITH ASBESTOS CAN BE DANGEROUS. INHALING ASBESTOS FIBERS HAS BEEN LINKED WITH VARIOUS TYPES OF CANCER IF YOU SMOKE AND INHALE ASBESTOS FIBERS, THE CHANCE THAT YOU WILL DEVELOP LUNG CANCER IS GREATER THAN THAT OF THE NON-SMOKING PUBLIC.

Your employer's contract with the Owner for the above project requires that: You be supplied with the proper respirator and be trained in its use. You be trained in safe work practices and in the use of the equipment found on the job. You receive a medical examination. These things are to have been done at no cost to you. By signing this certification you are assuring the Owner that your employer has met these obligations to you.

RESPIRATORY PROTECTION: I have been trained in the proper use of respirators, and informed ofthe type respirator to be used on the above referenced project. I have a copy of the written respiratory protection manual issued by my employers. I have been equipped at no cost with the respirator to be used on the above project.

TRAINING COURSE: I have been trained in the dangers inherent in handling asbestos and breathing asbestos dust and in proper work procedures and personal and area protective measures. The topics covered in the course included the following:

Physical characteristics of asbestos
Health hazards associated with asbestos
Respiratory protection
Use of protective equipment
Pressure differential systems
Work practices including hands-on or on-the-job training
Personal decontamination procedures
Air monitoring, personal and area

MEDICAL EXAMINATION: I have had a medical examination within the last 12 months which was paid for by my employer. This examination included: health history, pulmonary function tests and may have included an evaluation of a chest x-ray.

Signature _____ Witness _____

Printed Name _____ Social Security Number _____

CERTIFICATION OF VISUAL INSPECTION

AREA _____

In accordance with Paragraph "Project Decontamination" the Contractor hereby certifies that he has visually inspected the work area (all surfaces including pipes, beams, ledges, walls, ceiling and floor, Decontamination Unit, sheet plastic, etc.) and has found no dust, debris or residue.

By: _____

Signature _____ Date _____

Print Name _____

Print Title _____

OWNER'S REPRESENTATIVE CERTIFICATION

The Owner's Representative hereby certifies that he has accompanied the Contractor on his visual inspection and verifies that this inspection has been thorough and to the best of his knowledge and belief, the Contractor's certification above is a true and honest one.

Signature _____ Date _____

Print Name _____

Print Title _____

NEW YORK CITY DEPARTMENT OF DESIGN + CONSTRUCTION

RESPIRATORY PROTECTION PROGRAM

Project Name _____

Location _____

Date _____

Based upon airborne asbestos-fiber counts encountered on previous projects of similar type working on materials similar to those found on the above referenced project. The following level of respiratory protection is proposed for the indicated operations to maintain an Airborne Fiber Count (as measured by the NIOSH 7400 Method) below the specified Permissible Exposure Limit (PEL) inside the respirator face piece.

Operation	Anticipated f/cc	Respiratory Protection	Protection Factor	f/cc in Mask
Installing sheet plastic				
Removing trim in contact with asbestos-containing material				
Removal of architectural finish or fireproofing				
Removal of pipe insulation				
Removal of fitting insulation				
Encapsulation of pipe and boiler insulation				
Gross debris removal				
Cleaning "primary" sheet plastic				
Cleaning "critical" barrier				
Removing Decontamination Unit				
Other				

The Contractor certifies that to the best of his knowledge and belief the above represent a true and accurate representation of Airborne Fiber Counts to be expected for the operations indicated, and are based upon airborne fiber data from past projects with similar materials and operations.

Contractor _____

Signature _____ Date _____

Print Name _____ Title _____

END OF SECTION 13281a

SECTION 13281b - REMOVAL OF NONFRIABLE ASBESTOS-CONTAINING MATERIALS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for removal of nonfriable asbestos-containing materials. Products shall be as follows or as directed by the the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definitions

1. ACM: Asbestos Containing material which is any material containing more than one percent asbestos.
2. Amended Water: Water containing a wetting agent or surfactant with a maximum surface tension of 2.9 Pa 29 dynes per centimeter when tested in accordance with ASTM D 1331.
3. Area Sampling: Sampling of asbestos fiber concentrations which approximates the concentrations of asbestos in the theoretical breathing zone but is not actually collected in the breathing zone of an employee.
4. Asbestos: The term asbestos collectively refers to a naturally occurring mineral known by the following specific names: chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.
5. Asbestos control Area: That area where asbestos removal operations are performed. The area shall be isolated by physical boundaries to assist in the prevention of the uncontrolled access by non-qualified persons.
6. Asbestos Fibers: Those fibers having an aspect ratio of at least 3:1 and longer than-5 micrometers as determined by National Institute for Occupational Safety and Health (NIOSH) Method 7400.
7. Asbestos Permissible Exposure Limit: 0.1 fibers per cubic centimeter of air as an e-hour time weighted average measured in the breathing zone as by defined 29 CFR 1926.1101 or other Federal legislation having legal jurisdiction for the protection of workers health.
8. Background: The ambient airborne asbestos concentration in an uncontaminated area as measured prior to any asbestos hazard abatement efforts. Background concentrations for contaminated areas are measured in similar but asbestos free locations.
9. Contractor: The Contractor is that individual, or entity under contract to the Owner to perform the herein listed work.
10. Contractor/Supervisor (Asbestos abatement): A person who has successfully completed training and is therefore accredited as a Contractor/Supervisor under a State Model Accreditation Plan or EPA Model Accreditation Plan as described in 40 CFR 763.
11. Critical Barrier: The layer of polyethylene sheeting that covers an opening or penetration in a room or area that is to become a negative pressure enclosure.
12. Encapsulation: The abatement of an asbestos hazard through the appropriate use of chemical encapsulants.
13. Encapsulants: Specific materials in various forms used to chemically or physically entrap asbestos fibers in various configurations to prevent these fibers from becoming airborne. There are four types of encapsulants as follows which must comply with performance requirements as specified herein.
    a. Removal Encapsulant (can be used as a wetting agent)
    b. Bridging Encapsulant (used to provide a tough, durable surface coating to asbestos containing material)
    c. Penetrating Encapsulant (used to penetrate the asbestos containing material encapsulating all asbestos fibers and preventing fiber release due to routine mechanical damage)
    d. Lock-Down Encapsulant (used to seal off or "lock-down" minute asbestos fibers left on surfaces from which asbestos containing material has been removed).
14. Friable Asbestos Material: Any material containing more than one percent asbestos that can be crumbled, pulverized, or reduced to powder by hand pressure when dry.

15. Glovebag Technique: Those asbestos removal and control techniques put forth in 29 CFR 1926.1101.
16. HEPA Filter Equipment: High efficiency particulate air (HEPA) filtered vacuum and/or exhaust ventilation equipment with a filter system capable of collecting and retaining asbestos fibers. Filters shall retain 99.97 percent of particles 0.3 microns or larger as indicated in UL 586.
17. the Owner: That qualified person employed directly by the Owner to monitor, sample, inspect the work, and advise the Owner.
18. Negative Pressure Enclosure (NPE): That engineering control technique described as a negative pressure enclosure in 29 CFR 1926.1101.
19. Non-friable Asbestos Material: Material that contains asbestos in which the fibers have been immobilized by a bonding agent, coating, binder, or other material so that the asbestos is well bound and will not normally release asbestos fibers during any appropriate use, handling, storage or transportation. It is understood that asbestos fibers may be released under other conditions such as demolition, renovation, removal, or mishap.
20. Personal Sampling: Air sampling which is performed to determine asbestos fiber concentrations within the breathing zone of a specific employee, as performed in accordance with 29 CFR 1926.1101.
21. Competent Person (CP): A person who has successfully completed training and is therefore accredited under a legitimate State Model Accreditation Plan or EPA Model Accreditation Plan as described in 40 CFR 763 as a Contractor/Supervisor and shall be appropriately licensed according to the Statutes of the State in which the work is to be performed.
22. TEM: Refers to Transmission Electron Microscopy.
23. Time Weighted Average (TWA): The TWA is an 8-hour time weighted average airborne concentration of asbestos fibers.
24. Wetting Agent: A chemical added to water to reduce the water's surface tension thereby increasing the water's ability to soak into the material to which it is applied. An equivalent wetting agent must have a surface tension of at most 2.9 Pa 29 dynes per centimeter when tested in accordance with ASTM D 1331.

C. Requirements

1. Description of Work: The work covered by this section includes the handling and control of asbestos containing materials and describes some of the resultant procedures and equipment required to protect workers, the environment and occupants of the building or area, or both, from contact with airborne asbestos fibers. The work also includes the disposal of any asbestos containing materials generated by the work. More specific operational procedures shall be outlined in the Asbestos Hazard Abatement Plan called for elsewhere in this specification. The asbestos work includes the use of non-friable removal technique(s) which is governed by 40 CFR 763 as indicated. Provide non-friable removal technique(s) as outlined in this specification for the locations indicated.
2. Medical Requirements: Provide medical requirements including but not limited to medical surveillance and medical record keeping as listed in 29 CFR 1926.1101.
   a. Medical Examinations: Before exposure to airborne asbestos fibers, provide workers with a comprehensive medical examination as required by 29 CFR 1926.1101 or other pertinent State or local directives. This requirement must have been satisfied within the 12 months prior to the start of work on this contract. The same medical examination shall be given on an annual basis to employees engaged in an occupation involving asbestos and within 30 calendar days before or after the termination of employment in such occupation. Specifically identify x-ray films of asbestos workers to the consulting radiologist and mark medical record jackets with the word "ASBESTOS."
   b. Medical Records: Maintain complete and accurate records of employees' medical examinations, medical records, and exposure data for a period of 30 years after termination of employment and make records of the required medical examinations and exposure data available for inspection and copying to: The Assistant Secretary of Labor for Occupational

Safety and Health (OSHA), or authorized representatives of them, and an employee's physician upon the request of the employee or former employee.

c. Medical Certification: Submit written certification for each worker and contractor/supervisor, signed by a licensed physician indicating that the worker and contractor/supervisor has met or exceeded all of the medical prerequisites listed herein and in 29 CFR 1926.1101 and 29 CFR 1910.134 as prescribed by law.

3. Training: Train all personnel involved in the asbestos control work in accordance with United States Environmental Protection Agency (USEPA) Asbestos Hazard Emergency Response Act (AHERA) training criteria or State training criteria whichever is more stringent. The Contractor shall document the training by providing a copy of a current training certification to the the Owner for each person assigned to work on this project. Furnish each employee with respirator training and fit testing documentation as required by 29 CFR 1910.134. Provide instruction on the engineering and other hazard control techniques and procedures to be used on this project.

   a. Employee Training: Submit copies of training certificates for each employee indicating that the employee has received training at the appropriate level in accordance with 40 CFR 763.

4. Permits, Licenses, and Notifications: Notify the local air pollution control district/agency and the the Owner in writing 10 working days prior to commencement of work in accordance with 40 CFR 61-SUBPART M or applicable state and local regulations. Obtain necessary permits or licenses in conjunction with asbestos removal, encapsulation, hauling, and disposal. Post the permit and/or license at the work site, visible from a non-controlled area. Notify the local fire department 3 days prior to removing fire-proofing material from the building including notice that the material contains asbestos.

5. Environment, Safety and Health Compliance: Comply with the applicable requirements of the current issue of 29 CFR 1926.1101, 40 CFR 61-SUBPART A, and 40 CFR 61-SUBPART M or applicable State or local regulations regarding handling, storing, transporting, and disposing of asbestos waste materials. Submit matters of interpretation of standards to the appropriate administrative agency for resolution before starting the work. Where the requirements of this specification, applicable regulations, or referenced documents vary, the most stringent requirement shall apply.

   a. Site Inspection: While performing asbestos engineering control work, the Contractor shall be subject to on-site inspection by the Federal, State, or local regulatory agencies and the Contracting Officer or his designated representative. If the work is found to be in violation of Federal, State, or local regulations or this specification, the Contracting Officer or his representative will issue a stop work order to be in effect immediately and until the violation is resolved. All related costs including standby time required to resolve the. violation shall be at the Contractor's expense.

6. Respiratory Protection Program: Establish and implement a respirator program as required by ANSI 288.2 and 29 CFR 1910.134. Submit a written program manual or operating procedure including methods of compliance with regulatory statutes.

   a. Respirator Program Records: Submit records of the respirator program as required by ANSI 288.2 and 29 CFR 1910.134.

7. Contractor/Supervisor (Asbestos Abatement): The Contractor shall be represented on-site by a trained contractor/Supervisor. This person shall be on-site at all times when asbestos work is in progress. The Qualified Person, as defined herein, can be the Contractor/Supervisor.

8. Hazard Communication: Adhere to all parts of 29 CFR 1910.1200 and 29 CFR 1926.59. Provide the Contracting Officer with a copy of the Material Safety Data Sheets (MSDS) for all materials brought to the site. Review the Asbestos Survey Report(s) provided by the the Owner, if any.

9. Asbestos Hazard Abatement Plan: Submit a detailed plan of the safety precautions such as lockout, tag-out, tryout, fall protection, and confined space entry procedures and equipment and work procedures to be used in the removal of materials containing asbestos. The plan shall be prepared by the Contractor (and reviewed and signed by an asbestos consultant (LAC) licensed according to the Statutes of the State in which the work is to be performed) for review and recommendation for approval by the the Owner. The plan shall be forwarded to the the Owner for final approval at least 10 days prior to beginning abatement activities. The plan shall include but not be limited to the detailed description of personal protective equipment and work practices to

be used including, but not limited to, respiratory protection, type of whole-body protection , the location of asbestos control areas including clean and dirty areas, buffer zones, showers, storage areas, change rooms, removal method, interface of trades involved in the construction, sequencing of asbestos related work, disposal plan, type of wetting agent and asbestos encapsulant to be used, locations of local exhaust equipment, planned air sampling strategies, and a detailed description of the method to be employed in order to control environmental pollution. The plan shall also include both fire and medical emergency response plans. The Asbestos Hazard Abatement Plan must be approved in writing prior to starting any asbestos work.

10. Testing Laboratory: Submit the name, address, and telephone number of each testing laboratory selected for the sampling, analysis, and reporting of airborne concentrations of asbestos fibers along with evidence that each laboratory selected holds the appropriate State license and/or permits and certification that each laboratory is American Industrial Hygiene Association (AIHA) accredited and that persons counting the samples have been judged proficient by current inclusion on the AIHA Asbestos Analysis Registry (AAR) and successful participation of the laboratory in the Proficiency Analytical Testing (PAT) Program. Where analysis to determine asbestos content in bulk materials or transmission electron microscopy is required, submit evidence that the laboratory is accredited by the National Institute of Science and Technology (NIST) under National Voluntary Laboratory Accreditation Program (NVLAP) for asbestos analysis.
11. Landfill Approval: Submit written evidence that the landfill for disposal is approved for asbestos disposal by the USEPA and State and local regulatory agency(s).
12. Waste Shipment Records/Asbestos Waste Manifest: Submit waste shipment records and/or asbestos manifest records, prepared in accordance with applicable Federal, State, or local regulations, signed and dated by an agent of the landfill, certifying the amount of asbestos materials delivered to the landfill, within 3 days after delivery.
13. Negative Exposure Assessment: Submit objective data demonstrating that the method(s) used for the specified non-friable ACM removal does not release airborne concentrations of asbestos fibers exceeding the TWA PEL or excursion limit. This data may be from previous work within the last 12 months or from initial exposure assessments on this project. Data from previous work must have been gathered by the firm employed on this contract, using workers trained to the same level, with the ACM and workplace conditions "closely resembling" the conditions for this contract.
14. Contractor Daily Reports: Prepare a written report for each day that asbestos work is being accomplished. The report should be submitted to the the Owner monthly. The report as a minimum shall include the following, where applicable:
    a. Daily Visual Inspection Reports: Prepare a written report documenting compliance with the Asbestos Hazard Abatement Plan and Federal, State, or local regulations.
    b. Air Sampling Reports: Complete fiber counting within 24 hours of the "time off" of the sample pump. Notify the the Owner immediately of any airborne levels of asbestos fibers in excess of the acceptable limits. Sampling results shall be submitted to the the Owner the day following receipt. The affected employees will be provided copies of the results where required by law within 3 working days. These results shall be signed by the air sampler and the testing laboratory employee that analyzed the sample.
    c. Pressure Differential Recordings for Local Exhaust System-Not Used
    d. Asbestos Disposal Quantity Report: The Contractor shall record and report daily the amount of asbestos containing material removed and the amount transported for disposal. Deliver the report for the previous day and cumulative totals with amounts of material removed reported in linear meters or square meters linear feet or square feet as described initially in this specification and the amounts of material transported for disposal reported in cubic meters yards.

D. Submittals
1. Submit the following in accordance with Section "Submittal Procedures."
    a. Vacuums and tools

b. Respirators
c. Wetting Agent
d. Material Safety Data Sheets (MSDS) for all materials proposed for transport to the project site
e. Local exhaust system
f. Pressure differential automatic recording instrument
g. Daily Reports
h. Asbestos hazard abatement plan
i. Testing laboratory
j. Training Certificates
k. Landfill approval
l. Employee training
m. Medical certification requirements
n. Waste shipment records/Asbestos waste manifest
o. Respiratory Protection Program
p. Negative Exposure Assessment
q. Local Exhaust system
r. Show compliance with ANSI Z9.2 by providing manufacturers' certifications.
s. Permits, licenses, and Notifications
t. Rental equipment
u. Respirator program records
v. Protective clothing decontamination quality control records
w. Protective clothing decontamination facility notification.

E. Quality Assurance
1. Glovebags-Not Used
2. Rental Equipment: Provide a copy of the written notification to the rental company concerning the intended use of the equipment and the possibility of asbestos contamination of the equipment.
3. Protective Clothing Decontamination Quality Control Records: Provide all records that document quality control for the decontamination of reusable outer protective clothing.
4. Protective Clothing Decontamination Facility Notification: Submit written evidence that persons who decontaminate, store, or transport asbestos contaminated clothing used in the performance of this contract were duly notified in accordance with 29 CFR 1926.1101.

1.2 PRODUCTS

A. Encapsulants
1. See Division 02 Section "Facility Fire-suppression Water-service Piping".

1.3 EXECUTION

A. Equipment
1. Respirators: Select respirators from those approved by the National Institute for Occupational Safety and Health (NIOSH). Provide personnel engaged in pre-cleaning, cleanup, handling, and removal of asbestos containing materials with the appropriate respiratory protection as specified in 29 CFR 1910.134.
2. Exterior Whole Body Protection
a. Outer Protective Clothing: Provide personnel exposed to asbestos with disposable "non-breathable," or reusable "non-breathable" whole body outer protective clothing, head coverings, gloves, and foot coverings. Provide disposable plastic or rubber gloves to protect hands. Cloth gloves may be worn inside the plastic or rubber gloves for comfort, but shall not be used alone. Make sleeves secure at the wrists, make foot coverings secure at the ankles, and make clothing secure at the neck by the use of tape. Reusable whole body

outer protective clothing shall be either disposed of as asbestos contaminated waste upon exiting from the asbestos regulated work area or be properly decontaminated.

b. Work Clothing-Not Used

c. Decontamination of Reusable Outer Protective Clothing: When reusable outer protective clothing is used, transport the double bagged clothing to a previously notified commercial/industrial decontamination facility for decontamination. Perform non-destructive testing to determine the effectiveness of asbestos decontamination. If representative sampling is used, ensure the statistical validity of the sampling results. If representative sampling is used, reject any entire batch in which any of the pieces exceed 40 fibers per square millimeter. Inspect reusable protective clothing prior to use to ensure that it will provide adequate protection and is not or is not about to become ripped, torn, deteriorated, or damaged, and that it is not visibly contaminated. Notify, in writing, all personnel involved in the decontamination of reusable outer protective clothing as indicated in 29 CFR 1926.1101.

d. Eye Protection: Provide goggles to personnel engaged in asbestos abatement operations when the use of a full face respirator is not required.

3. Warning Signs and Labels: Provide bilingual warning signs printed in English and Spanish at all approaches to asbestos control areas. Locate signs at such a distance that personnel may read the sign and take the necessary protective steps required before entering the area. Provide labels and affix to all asbestos materials, scrap, waste, debris, and other products contaminated with asbestos.

a. Warning Sign: Provide vertical format conforming to 29 CFR 1926.1101 minimum 20 by 14 inches (500 by 355 mm) displaying the following legend in the lower panel:

Legend	Notation
Danger	25 mm one inch Sans Serif Gothic or Block
Asbestos	25 mm one inch Sans Serif Gothic or Block
Cancer and Lung Disease Hazard	6 mm 1/4 inch Sans Serif Gothic or Block
Authorized Personnel only	6 mm 1/4 inch Gothic
Respirators and Protective Clothing are Required in this Area	6 mm 1/4 inch Gothic

Spacing between lines shall be at least equal to the height of the upper of any two lines.

b. Warning Labels: Provide labels conforming to 29 CFR 1926.1101 of sufficient size to be clearly legible, displaying the following legend:

DANGER
CONTAINS ASBESTOS FIBERS
AVOID CREATING DUST
CANCER AND LUNG DISEASE HAZARD
BREATHING ASBESTOS DUST MAY
CAUSE SERIOUS BODILY HARM

4. Vacuums and Tools: Vacuums shall be leak proof to the filter and equipped with HEPA filters. Filters on vacuums shall conform to ANSI Z9.2 and UL 586. Do not use power tools to remove asbestos containing materials unless the tool is equipped with effective, integral HEPA filtered exhaust ventilation systems. Remove all residual asbestos from reusable tools prior to storage or reuse.

B. General

1. Pre-Asbestos Work Conference: The Contractor and the Contractor/Supervisor shall meet with the Contracting officer prior to beginning work, to discuss in detail the Asbestos Hazard Abatement Plan, including work procedures and safety precautions. Once approved by the Owners Engineer, the plan will be enforced as if a part of this specification. Any changes required in the specification as a result of the plan shall be identified specifically in the plan to allow for free discussion and approval by the Owners Engineer prior to starting work.
2. Asbestos Control Area Requirements: The Contractor shall demarcate the asbestos control area(s) using physical barriers and signs to prevent access by unauthorized personnel. This area is defined by 29 CFR 1926.1101 as the regulated area.
3. Work Procedure: Perform asbestos related work in accordance with 29 CFR 1926.1101, 40 CFR 61-SUBPART M, applicable State or local regulation, and as specified herein. Use wet removal procedures. Personnel shall wear and utilize protective clothing and equipment as specified herein. Eating, smoking, drinking, chewing gum or tobacco, or applying cosmetics shall not be permitted in the asbestos control area(s). Personnel of other trades not engaged in the removal of asbestos containing material shall not be exposed at any time to airborne concentrations of asbestos. If an asbestos fiber release or spill, stop work immediately, correct the condition to the satisfaction of the Owners Engineer, including clean-up and clearance sampling, if appropriate, prior to resumption of work.
4. Furnishings: Furniture will be removed from the area of work by the Owner before asbestos work begins.
5. Pre-cleaning: Wet wipe and HEPA vacuum all surfaces potentially contaminated with asbestos prior to establishment of an enclosure.

C. Removal Procedures: Wet asbestos containing material with a fine spray of amended water during removal, cutting, or other handling so as to reduce the emission of airborne fibers. Remove material and immediately place in 0.15 mm 6 mil plastic disposal bags. Remove asbestos containing material in a gradual manner, with continuous application of the amended water in such a manner that no asbestos material is disturbed prior to being adequately wetted. Where unusual circumstances prohibit the use of 0.15 mm 6 mil plastic bags, submit an alternate proposal for containment of asbestos fibers to the Owner's Engineer for approval. Asbestos containing material shall be containerized while wet. At no time shall asbestos containing material be allowed to accumulate or become dry. Handle asbestos containing material as indicated in 40 CFR 61-SUBPART M, applicable State or local regulation, and 29 CFR 1926.1101.

1. Exposed Pipe Insulation Edges-Not Used
2. Negative Pressure Enclosure: Block and seal openings in areas where the release of airborne asbestos fibers can be expected. Establish an asbestos negative pressure enclosure with the use of curtains, portable partitions, or other enclosures in order to prevent the escape of asbestos fibers from the contaminated asbestos work area.
   a. Personnel/Equipment Decontamination Unit: Provide a temporary facility with a separate equipment/dirty change room and clean change room. Provide a shower that complies with 29 CFR 1926.51 in between the dirty room and clean room for personnel required to wear whole body protective clothing. Provide two separate lockers for each asbestos worker, one in each locker room. Keep street clothing and street shoes in the clean locker. HEPA vacuum and remove asbestos contaminated disposable protective clothing while still wearing respirators at the boundary of the asbestos work area and seal in impermeable bags or containers for disposal. Do not wear work clothing between home and work. All employees shall shower before changing into street clothes. Collect used shower water and filter with approved water filtration equipment to remove asbestos contamination. Dispose of filters and residue as asbestos waste. Discharge clean water to the sanitary system. Dispose of asbestos contaminated work clothing as asbestos contaminated waste or properly decontaminate as specified in the Asbestos Hazard Abatement Plan.
   b. Waste Load-Out Unit: Provide a separate temporary area expressly for short-term storage of bagged asbestos containing material that is ready for disposal. The unit shall be the only port used to transfer waste to a truck, dumpster, or other approved on-site storage facility. It

shall not be used for personnel egress. A waste load-out unit shall be integral to each negative pressure enclosure.

3. Non-friable Removal Procedures:
   a. Under normal conditions EPA Category II, non-friable asbestos containing materials may not be considered hazardous; however, this material may release airborne asbestos fibers during demolition and removal; therefore it must be handled in a manner to prevent the release of asbestos fibers. At no time will this material be mechanically chipped, sawed, sanded, or ground.
   b. Prior to beginning removal, establish an Asbestos Control Area and install Critical Barriers as specified elsewhere in this section. Submit a Negative Exposure Assessment which is less than 12 months old to the the Owner for approval or conduct air sampling as specified elsewhere in this section to establish the exposure levels for the exact removal method being used. The Contractor will establish the correct level of Personal Protective Equipment required.
   c. Acceptable methods of removal include, but are not limited to, the use of dry ice, a heat gun or lamp, citrus-based solvents, and hand tools with amended water. Removal shall be accomplished to keep the ACM substantially intact. Breakage into small pieces is an unacceptable work practice. The method shall-be detailed in the Asbestos Abatement Plan and shall not be changed during the removal without Contracting Officer approval.
   d. Upon completion of the removal and clean-up, but prior to removal of critical barriers, the Contractor Testing company shall conduct a visual inspection of all areas affected by the removal. Re-clean as required.

D. Field Quality Control Requirements
   1. Visual Inspections: The the Owner will conduct periodic inspections of all areas where asbestos removal and activities are in progress to ensure compliance with the approved Asbestos Hazard Abatement Plan and Federal/State regulatory requirements. This inspection shall include confirmation of proper control/containment/enclosure, worker protection, housekeeping, exhaust equipment operation, decontamination procedures, proper wetting and disposal, and inspection of work progress and work practices. Each activity will be documented as acceptable or noted as unacceptable with justification for the non-compliance.
   2. Air Sampling: Sampling of airborne concentrations of asbestos fibers shall be performed in accordance with 29 CFR 1926.1101 and as specified herein. Unless otherwise specified, use NIOSH Method 7400 for sampling and analysis. Air Sampling may be duplicated by the Government at the discretion of the Contracting Officer. If the air sampling results obtained by the Government differ from those results obtained by the Contractor, the Government will determine which results predominate.
      a. Sampling Prior to Asbestos Work (Not Used)
      b. Sampling During Asbestos Work
         1) The Contractor's testing company shall perform area sampling as indicated in 29 CFR 1926.1101 and governing environmental regulations. Perform area sampling at least once every week close to the work inside the enclosure, outside the personnel/equipment decontamination unit entrance to the enclosure.
         2) If sampling outside the enclosure shows airborne levels have exceeded background or 0.01 fibers per cubic centimeter, whichever is greater, stop all work, correct the condition(s) causing the fiber release, and notify the the Owner immediately. Determine by testing if adjacent areas are contaminated. If so the Contractor shall clean the contaminated areas, visually inspect, and sample the areas as specified herein.
         3) The Contractor shall conduct personal sampling of at least 25% of the workers engaged in asbestos handling (removal, disposal, transport and other associated work) throughout the duration of the project. If the quantity of airborne asbestos fibers monitored at the breathing zone of the workers at any time exceeds 0.1 fibers

per cubic centimeter, notify the PQP immediately, evaluate work practices, and take corrective action to reduce airborne asbestos fibers.

E. Clean-Up And Disposal

1. Housekeeping

a. Essential parts of asbestos dust control are housekeeping and clean-up procedures. Maintain surfaces of the asbestos control area free of accumulations of asbestos fibers. Give meticulous attention to restricting the spread of dust and debris; keep waste from being distributed over the general area. Use HEPA filtered vacuum cleaners. DO NOT BLOW DOWN THE SPACE WITH COMPRESSED AIR. All asbestos waste shall be placed in an approved on-site storage facility or transported for disposal daily. When asbestos removal is complete, all asbestos waste is removed from the work-site, and final clean-up is completed, the PQP shall visually inspect the asbestos control area for cleanliness. After final clean-up and acceptable pre-clearance airborne concentrations are attained but before the local exhaust system is turned off and the negative pressure enclosure removed), remove all pre-filters on the building HVAC system and provide new pre-filters.

b. Dispose of filters as asbestos contaminated materials. Reestablish HVAC,. mechanical, and electrical systems in proper working order.

2. Title to Materials: All waste materials, except as specified otherwise, shall become the property of the Contractor and shall be disposed of as specified in applicable Federal, State, and local regulations and herein.

3. Disposal of Asbestos

a. Collect all removed asbestos containing material, contaminated materials, contaminated water, scrap, debris, bags, containers, expendable equipment, and asbestos contaminated clothing which may produce airborne asbestos fibers and place in sealed fiber-proof, waterproof, non-returnable containers (e.g. double plastic bags 0.15 mm 6 mils thick, cartons, drums or cans). Wastes within the containers must be adequately wet in accordance with 40 CFR 61-SUBPART M. Affix a warning and Department of Transportation (DOT) label to each container including the bags or use at least 0.15 mm 6 mils thick bags with the approved warnings and DOT labeling preprinted on the bag.

b. Each container or bag shall clearly indicate that the waste generator is the Owner and the development at which the waste is generated, and the Job Order number of the project.

c. Prevent contamination of the transport vehicle (especially if the transport vehicle is a rented truck likely to be used in the future for non-asbestos purposes). These precautions include lining the vehicle cargo area with plastic sheeting (similar to work area enclosure) and thorough cleaning of the cargo area after transport and unloading of asbestos debris is complete. Dispose of waste asbestos material at an Environmental Protection Agency (EPA) or State-approved asbestos landfill off the Owner's property. For temporary storage, store sealed impermeable bags in asbestos waste drums or skids. An area for interim storage of asbestos waste-containing drums or skids will be coordinated with the the Owner. Procedure for hauling and disposal shall comply with 40 CFR 61-SUBPART M, State, regional, and local standards. Sealed plastic bags may be dumped from drums into the burial site unless the bags have been broken or damaged. Damaged bags shall remain in the drum and the entire contaminated drum shall be buried. Uncontaminated drums may be recycled. Workers unloading the sealed drums shall wear appropriate respirators and personal protective equipment when handling asbestos materials at the disposal site.

END OF SECTION 13281b

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SECTION 13281c - ENCAPSULATION (LOCK-DOWN) OF ASBESTOS-CONTAINING MATERIALS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for encapsulation (lock-down) of asbestos-containing materials. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: Manufacturers technical information including label analysis and application instructions for each material proposed for use.
2. Installation Instructions: Manufacturer's installation instructions with specific project requirements noted.
3. Performance Warrantee: Manufacturers performance guarantee.
4. Material Safety Data Sheet: Material Safety Data Sheet in accordance with the OSHA Hazard Communication Standard (29 CFR 1910.1200) for each surfactant and encapsulating material proposed for use on the work. Include a separate attachment for each sheet indicating the specific worker protective equipment proposed for use with the material indicated.

C. Delivery And Storage: Deliver materials to the job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:
1. Name or title of material
2. Manufacturer's stock number and date of manufacture
3. Manufacturer's name
4. Thinning instructions
5. Application instructions
6. Deliver materials together with a copy of the OSHA Material
7. Safety Data Sheet for the material.

D. Job Conditions: Apply encapsulating materials only when environmental conditions in the work area are as required by the manufacturer's instructions.

E. Quality Assurance
1. Testing: Test material to be encapsulated using methods set forth in ASTM E1494 “Standard Practice for Encapsulants for Spray-or-Trowel-Applied Friable Asbestos- Containing Building Materials."

F. Warranty
1. Performance Warranty: Contractor shall submit written Performance Warranty, executed by the contractor, agreeing to repair/replace spray-on work which has cracked, fallen from substrate, or otherwise deteriorated to a condition where it would not perform effectively for its intended purposes due substantially to defective materials or workmanship and not due to abuse by occupants, improper maintenance, unforeseeable ambient exposures or other causes beyond anticipated conditions and contractors control. Warranty period shall be for at least one year after date of substantial completion.

1.2 PRODUCTS

A. Materials

1. Encapsulant system shall be an acrylic, elastomeric type, spray, brush or roller-applied, tinted penetrating or tinted bridging type, specifically designed for application to asbestos-containing material. System shall be equal to Global Encasement System as manufactured by GLOBAL Encasement Inc., 132-32nd Street, Union City, NJ 07087 U.S.A., Tel. (800) 266-3982/(201) 902-9770.
   a. All encasement topcoat materials shall be warranted to be heavy-bodied, from the same manufacturer, and shall be long lasting, highly-pure (low VOC) materials that remain flexible, chalk resistant and resist cracking, peeling, algae and fungus that can cause future indoor air quality concerns.
   b. To allow for building movement without cracking or disturbing fibrous materials, coating systems shall have passed testing to ASTM standards for adhesion, permeability, aged flexibility and with aged elasticity for the encasement system of over 250%.
   c. Coatings shall be Class A Fire Rated, water-based, non-toxic, safe and easy to use, contain no hazardous ingredients by OSHA definition, comply with all known building codes and be non-flammable.
   d. Coating materials shall have low VOC (Volatile Organic Compound) content.
   e. Coating materials shall not release health threatening toxic smoke and fumes in a fire and shall comply with all known building codes.
   f. Coating materials shall have passed the following testing standards:
      1) ASTM E 119 fire tests demonstrating that applying a multi-layer system over fireproofing does not adversely affect the fireproof rating of the fireproofing (3 hour test).
      2) UPITT Combustion Toxicity Test proving nothing toxic is released in a fire.
      3) ASTM E 84 and E162 fire tests for "Class A" - Surface Flammability and Burning Characteristics (Flame Spread = 0, Smoke Developed = 5).
      4) "Pull-off Adhesion" test per ASTM E736 equals or exceeds 9,950 lbs./sq. ft. (89.1 lbs./sq. in.).
      5) ASTM D 1653 and E96 "Water Vapor Permeability" (showing the rate that water vapor can pass through the system).
      6) Impact Resistance, "Tensile Strength" shall exceed 150 psi; "Elongation" shall exceed 250%.
      7) System shall be mildew resistant, impact resistant, scrub resistant, non-yellowing, non-chalking, highly blister resistant, rust resistant, highly chemical resistant and shall remain flexible after 1000 hour ASTM Accelerated Weather testing.
      8) Water-Based materials (low VOC) Volatile Organic Content of Primer-Sealer-Neutralizer = 0.1 g/L (0.001 lb./gal.) and Encasement Top Coat = 0.1 g/L (0.001 lb./gal.) as tested by EPA Method 24.
      9) Materials comply with applicable standards for installation on interior and/or exterior surfaces of a building.
      10) Encasement Systems shall provide additional water-proofing protection.

B. Related Materials:
   1. Elastomeric architectural sealants, caulking compounds, primers, and similar materials shall be approved by the manufacturer of the encasement coatings. All materials used shall be applied in accordance with its manufacturer's recommendations.

C. Applicable Standards
   1. Product shall be rated as acceptable for use intended when field tested in accordance with ASTM E 1494.

1.3 EXECUTION

A. General

1. Prior to applying any encapsulating material in Work Areas, Contractor shall obtain final visual inspection approval by the Project Administrator.
2. Prior to applying any encapsulating material, Contractor shall ensure that application of the sealer will not cause the base material to fail and allow the sealed material to fall of its own weight or separate from the substrate. Should Contractor doubt the ability of the installation to support the sealant, request direction from the Owner's Representative before proceeding with the encapsulating work.
3. Do Not Commence Application of encapsulating materials until all removal work within the work area has been completed.

B. Worker Protection
1. Before beginning work with any material for which a Material Safety Data Sheet has been submitted provide workers with the required protective equipment. Require that appropriate protective equipment be used at all times.

C. Application
1. Comply with all manufacturer's instructions for particular conditions of installation. Consult with manufacturer's technical representative for conditions not covered.
2. Encapsulate all surfaces in full compliance with manufacturer's procedures.
3. At completion of Encapsulation and before removal of Work Area enclosures and Pressure Differential System, decontaminate space in accordance with requirements of manufacturer’s instructions.
4. Remove all debris from the project site and restore area to proper conditions by cleaning all surfaces in accordance with manufacturer’s written recommendations.
5. At completion of work submit manufacturer’s record of inspection of completed work and Manufacturers Performance Guarantee executed by both manufacturer and Contractor.

END OF SECTION 13281c

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Task	Specification	Specification Description
13281	01352	No Specification Required

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SECTION 13283 - MOLD REMEDIATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the removal and disposal of mold. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. List of all personnel to be involved in the work with their training and certifications.
2. List of all products and procedures proposed for use in performance of the work.
3. Test reports.
4. Certificates.

C. References
1. U.S. EPA “Mold Remediation in Schools and Commercial Buildings”
2. U.S. EPA “A Brief Guide to Mold, Moisture, and Your Home”

D. Quality Assurance
1. Conform to all Federal, State, and Local regulations which govern the handling and disposal of mold materials.

1.2 PRODUCT - (Not Used)

1.3 EXECUTION

A. Environmental Assessment: The presence of mold, water damage, or musty odors shall be addressed immediately. In all instances, any source(s) of water must be stopped and the extent of water damaged determined. Water damaged materials shall be dried and repaired. Mold damaged materials shall be remediated in accordance with this document.
1. Visual Inspection: A visual inspection is the most important initial step in identifying a possible contamination problem. The extent of any water damage and mold growth shall be visually assessed. This assessment is important in determining remedial strategies. Ventilation systems shall also be visually checked, particularly for damp filters but also for damp conditions elsewhere in the system and overall cleanliness. Ceiling tiles, gypsum wallboard (sheetrock), cardboard, paper, and other cellulosic surfaces shall be given careful attention during a visual inspection. The use of equipment such as a boroscope, to view spaces in ductwork or behind walls, or a moisture meter, to detect moisture in building materials, may be helpful in identifying hidden sources of fungal growth and the extent of water damage.
2. Bulk/Surface Sampling
a. Bulk or surface sampling is not required to undertake a remediation. Remediation of visually identified fungal contamination shall proceed without further evaluation.
b. Bulk or surface samples may need to be collected to identify specific fungal contaminants as part of a medical evaluation if occupants are experiencing symptoms which may be related to fungal exposure or to identify the presence or absence of mold if a visual inspection is equivocal (e.g., discoloration, and staining).
c. An individual trained in appropriate sampling methodology shall perform bulk or surface sampling. Bulk samples shall be collected from visibly moldy surfaces by scraping or cutting materials with a clean tool into a clean plastic bag. Surface samples shall be collected by wiping a measured area with a sterile swab or by stripping the suspect surface

with clear tape. Surface sampling is less destructive than bulk sampling. Other sampling methods may also be available. A laboratory specializing in mycology shall be consulted for specific sampling and delivery instructions.

3. Air Monitoring
   a. Air sampling for fungi shall not be part of a routine assessment. This is because decisions about appropriate remediation strategies can usually be made on the basis of a visual inspection. In addition, air-sampling methods for some fungi are prone to false negative results and therefore cannot be used to definitively rule out contamination.
   b. Air monitoring may be necessary if an individual(s) has been diagnosed with a disease that is or may be associated with a fungal exposure (e.g., pulmonary hemorrhage/hemosiderosis, and aspergillosis).
   c. Air monitoring may be necessary if there is evidence from a visual inspection or bulk sampling that ventilation systems may be contaminated. The purpose of such air monitoring is to assess the extent of contamination throughout a building. It is preferable to conduct sampling while ventilation systems are operating.
   d. Air monitoring may be necessary if the presence of mold is suspected (e.g., musty odors) but cannot be identified by a visual inspection or bulk sampling (e.g., mold growth behind walls). The purpose of such air monitoring is to determine the location and/or extent of contamination.
   e. If air monitoring is performed, for comparative purposes, outdoor air samples shall be collected concurrently at an air intake, if possible, and at a location representative of outdoor air. For additional information on air sampling, refer to the American Conference of Governmental Industrial Hygienists' document, "Bioaerosols: Assessment and Control."
   f. Personnel conducting the sampling shall be trained in proper air sampling methods for microbial contaminants. A laboratory specializing in mycology shall be consulted for specific sampling and shipping instructions.
4. Analysis of Environmental Samples
   a. Microscopic identification of the spores/colonies requires considerable expertise. These services are not routinely available from commercial laboratories. Documented quality control in the laboratories used for analysis of the bulk/surface and air samples is necessary. The American Industrial Hygiene Association (AIHA) offers accreditation to microbial laboratories (Environmental Microbiology Laboratory Accreditation Program (EMLAP)). Accredited laboratories must participate in quarterly proficiency testing (Environmental Microbiology Proficiency Analytical Testing Program (EMPAT)).
5. Evaluation of bulk/surface and air sampling data shall be performed by an experienced health professional. The presence of few or trace amounts of fungal spores in bulk/surface sampling shall be considered background. Amounts greater than this or the presence of fungal fragments (e.g., hyphae, and conidiophores) may suggest fungal colonization, growth, and/or accumulation at or near the sampled location. Air samples shall be evaluated by means of comparison (i.e., indoors to outdoors) and by fungal type (e.g., genera, and species). In general, the levels and types of fungi found should be similar indoors (in non-problem buildings) as compared to the outdoor air. Differences in the levels or types of fungi found in air samples may indicate that moisture sources and resultant fungal growth may be problematic.

B. Remediation
1. General
   a. **In all situations, the underlying cause of water accumulation must be rectified or fungal growth will recur.** Any initial water infiltration shall be stopped and cleaned immediately. An immediate response (within 24 to 48 hours) and thorough clean up, drying, and/or removal of water damaged materials will prevent or limit mold growth. If the source of water is elevated humidity, relative humidity shall be maintained at levels below 60% to inhibit mold growth. Emphasis shall be on ensuring proper repairs of the building infrastructure, so that water damage and moisture buildup does not recur.
   b. Five different levels of abatement are described below. The size of the area impacted by fungal contamination primarily determines the type of remediation. The sizing levels below

are based on professional judgment and practicality; currently there is not adequate data to relate the extent of contamination to frequency or severity of health effects. **The goal of remediation is to remove or clean contaminated materials in a way that prevents the emission of fungi and dust contaminated with fungi from leaving a work area and entering an occupied or non-abatement area, while protecting the health of workers performing the abatement.** The listed remediation methods were designed to achieve this goal, however, due to the general nature of these methods it is the responsibility of the people conducting remediation to ensure the methods enacted are adequate. The listed remediation methods are not meant to exclude other similarly effective methods. Any changes to the remediation methods listed in these guidelines, however, shall be carefully considered prior to implementation.

c. Non-porous (e.g., metals, glass, and hard plastics) and semi-porous (e.g., wood, and concrete) materials that are structurally sound and are visibly moldy can be cleaned and reused. Cleaning shall be done using a detergent solution. Porous materials such as ceiling tiles and insulation, and wallboards with more than a small area of contamination shall be removed and discarded. Porous materials (e.g., wallboard, and fabrics) that can be cleaned, can be reused, but should be discarded if possible. A professional restoration consultant shall be contacted when restoring porous materials with more than a small area of fungal contamination. All materials to be reused shall be dry and visibly free from mold. Routine inspections shall be conducted to confirm the effectiveness of remediation work.

d. The use of gaseous, vapor-phase, or aerosolized biocides for remedial purposes is **not** recommended. The use of biocides in this manner can pose health concerns for people in occupied spaces of the building and for people returning to the treated space if used improperly. Furthermore, the effectiveness of these treatments is unproven and does not address the possible health concerns from the presence of the remaining non-viable mold. For additional information on the use of biocides for remedial purposes, refer to the American Conference of Governmental Industrial Hygienists' document, "Bioaerosols: Assessment and Control."

2. ***Level I***: **Small Isolated Areas** (10 sq. ft or less) - e.g., ceiling tiles, small areas on walls

a. Remediation can be conducted by regular building maintenance staff. Such persons shall receive training on proper clean up methods, personal protection, and potential health hazards. This training can be performed as part of a program to comply with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).

b. Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.

c. The work area shall be unoccupied. Vacating people from spaces adjacent to the work area is not necessary but is recommended in the presence of infants (less than 12 months old), persons recovering from recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).

d. Containment of the work area is not necessary. Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.

e. Contaminated materials that cannot be cleaned shall be removed from the building in a sealed plastic bag. There are no special requirements for the disposal of moldy materials.

f. The work area and areas used by remedial workers for egress shall be cleaned with a damp cloth and/or mop and a detergent solution.

g. All areas shall be left dry and visibly free from contamination and debris.

3. ***Level II***: **Mid-Sized Isolated Areas** (10 - 30 sq. ft.) - e.g., individual wallboard panels.

a. Remediation can be conducted by regular building maintenance staff. Such persons shall receive training on proper clean up methods, personal protection, and potential health hazards. This training can be performed as part of a program to comply with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).

b. Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.

c. The work area shall be unoccupied. Vacating people from spaces adjacent to the work area is not necessary but is recommended in the presence of infants (less than 12 months old), persons having undergone recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
d. The work area shall be covered with a plastic sheet(s) and sealed with tape before remediation, to contain dust/debris.
e. Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
f. Contaminated materials that cannot be cleaned shall be removed from the building in sealed plastic bags. There are no special requirements for the disposal of moldy materials.
g. The work area and areas used by remedial workers for egress shall be HEPA vacuumed (a vacuum equipped with a High-Efficiency Particulate Air filter) and cleaned with a damp cloth and/or mop and a detergent solution.
h. All areas shall be left dry and visibly free from contamination and debris.

4. ***Level III*: Large Isolated Areas** (30 - 100 square feet) - e.g., several wallboard panels.
   a. A health and safety professional with experience performing microbial investigations shall be consulted prior to remediation activities to provide oversight for the project.
   b. The following procedures *at a minimum* are recommended:
      1) Personnel trained in the handling of hazardous materials and equipped with respiratory protection, (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.
      2) The work area and areas directly adjacent shall be covered with a plastic sheet(s) and taped before remediation, to contain dust/debris.
      3) Seal ventilation ducts/grills in the work area and areas directly adjacent with plastic sheeting.
      4) The work area and areas directly adjacent shall be unoccupied. Further vacating of people from spaces near the work area is recommended in the presence of infants (less than 12 months old), persons having undergone recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
      5) Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
      6) Contaminated materials that cannot be cleaned shall be removed from the building in sealed plastic bags. There are no special requirements for the disposal of moldy materials.
      7) The work area and surrounding areas shall be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution.
      8) All areas shall be left dry and visibly free from contamination and debris.
   c. If abatement procedures are expected to generate a lot of dust (e.g., abrasive cleaning of contaminated surfaces, demolition of plaster walls) or the visible concentration of the fungi is heavy (blanket coverage as opposed to patchy), then it is recommended that the remediation procedures for Level IV are followed.

5. ***Level IV*: Extensive Contamination** (greater than 100 contiguous square feet in an area)
   a. A health and safety professional with experience performing microbial investigations shall be consulted prior to remediation activities to provide oversight for the project. The following procedures are recommended:
      1) Personnel trained in the handling of hazardous materials equipped with:
         a) Full-face respirators with high efficiency particulate air (HEPA) cartridges
         b) Disposable protective clothing covering both head and shoes
         c) Gloves
      2) Containment of the affected area:

a) Complete isolation of work area from occupied spaces using plastic sheeting sealed with duct tape (including ventilation ducts/grills, fixtures, and any other openings)
b) The use of an exhaust fan with a HEPA filter to generate negative pressurization
c) Airlocks and decontamination room

3) Vacating people from spaces adjacent to the work area is not necessary but is recommended in the presence of infants (less than 12 months old), persons having undergone recent surgery, immune suppressed people, or people with chronic inflammatory lung diseases (e.g., asthma, hypersensitivity, pneumonitis, and severe allergies).
4) Contaminated materials that cannot be cleaned shall be removed from the building in sealed plastic bags. The outside of the bags shall be cleaned with a damp cloth and a detergent solution or HEPA vacuumed in the decontamination chamber prior to their transport to uncontaminated areas of the building. There are no special requirements for the disposal of moldy materials.
5) The contained area and decontamination room shall be HEPA vacuumed and cleaned with a damp cloth and/or mop with a detergent solution and be visibly clean prior to the removal of isolation barriers.
6) Air monitoring shall be conducted prior to occupancy to determine if the area is fit to reoccupy.

6. ***Level V***: Remediation of HVAC Systems

a. A Small Isolated Area of Contamination (<10 square feet) in the HVAC System

1) Remediation can be conducted by regular building maintenance staff. Such persons shall receive training on proper clean up methods, personal protection, and potential health hazards. This training can be performed as part of a program to comply with the requirements of the OSHA Hazard Communication Standard (29 CFR 1910.1200).
2) Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended. Gloves and eye protection shall be worn.
3) The HVAC system shall be shut down prior to any remedial activities.
4) The work area shall be covered with a plastic sheet(s) and sealed with tape before remediation, to contain dust/debris.
5) Dust suppression methods, such as misting (not soaking) surfaces prior to remediation, are recommended.
6) Growth supporting materials that are contaminated, such as the paper on the insulation of interior lined ducts and filters, shall be removed. Other contaminated materials that cannot be cleaned shall be removed in sealed plastic bags. There are no special requirements for the disposal of moldy materials.
7) The work area and areas immediately surrounding the work area shall be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution.
8) All areas shall be left dry and visibly free from contamination and debris.
9) A variety of biocides are recommended by HVAC manufacturers for use with HVAC components, such as, cooling coils and condensation pans. HVAC manufacturers shall be consulted for the products they recommend for use in their systems.

b. Areas of Contamination (>10 square feet) in the HVAC System: A health and safety professional with experience performing microbial investigations shall be consulted prior to remediation activities to provide oversight for remediation projects involving more than a small isolated area in an HVAC system. The following procedures are recommended:

1) Personnel trained in the handling of hazardous materials equipped with:
a) Respiratory protection (e.g., N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134), is recommended.
b) Gloves and eye protection

c) Full-face respirators with HEPA cartridges and disposable protective clothing covering both head and shoes shall be worn if contamination is greater than 30 square feet.

2) The HVAC system shall be shut down prior to any remedial activities.

3) Containment of the affected area:

a) Complete isolation of work area from the other areas of the HVAC system using plastic sheeting sealed with duct tape.

b) The use of an exhaust fan with a HEPA filter to generate negative pressurization.

c) Airlocks and decontamination room if contamination is greater than 30 square feet.

4) Growth supporting materials that are contaminated, such as the paper on the insulation of interior lined ducts and filters, shall be removed. Other contaminated materials that cannot be cleaned should be removed in sealed plastic bags. When a decontamination chamber is present, the outside of the bags shall be cleaned with a damp cloth and a detergent solution or HEPA vacuumed prior to their transport to uncontaminated areas of the building. There are no special requirements for the disposal of moldy materials.

5) The contained area and decontamination room shall be HEPA vacuumed and cleaned with a damp cloth and/or mop and a detergent solution prior to the removal of isolation barriers.

6) All areas shall be left dry and visibly free from contamination and debris.

7) Air monitoring shall be conducted prior to re-occupancy with the HVAC system in operation to determine if the area(s) served by the system are fit to reoccupy.

8) A variety of biocides are recommended by HVAC manufacturers for use with HVAC components, such as, cooling coils and condensation pans. HVAC manufacturers shall be consulted for the products they recommend for use in their systems.

7. Hazard Communication: When fungal growth requiring large-scale remediation is found, the building owner, management, and/or employer shall notify occupants in the affected area(s) of its presence. Notification shall include a description of the remedial measures to be taken and a timetable for completion. Group meetings held before and after remediation with full disclosure of plans and results can be an effective communication mechanism. Individuals with persistent health problems that appear to be related to bioaerosol exposure should see their physicians for a referral to practitioners who are trained in occupational/environmental medicine or related specialties and are knowledgeable about these types of exposures. Individuals seeking medical attention shall be provided with a copy of all inspection results and interpretation to give to their medical practitioners.

END OF SECTION 13283

SECTION 13285 - REMOVAL AND DISPOSAL OF LEAD-CONTAINING PAINT

1.1 GENERAL

A. Description Of Work

1. This specification covers the removal and disposal of lead-based or lead-containing paint. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Definitions

1. Action Level: Employee exposure, without regard to use of respirators, to an airborne concentration of lead of 30 micrograms per cubic meter of air averaged over an 8 hour period in an occupational/industrial environment.
2. Area Sampling: Sampling of lead concentrations within the lead control area and inside the physical boundaries which is representative of the airborne lead concentrations but is not collected in the breathing zone of personnel.
3. Competent Person (CP): As used in this section, refers to a person employed by the Contractor who is trained in the recognition and control of lead hazards in accordance with current federal, State, and local regulations. An industrial hygienist or safety professional certified for comprehensive practice by the American Board of Industrial Hygiene or by the Board of Certified Safety Professionals is the best choice.
4. Contaminated Room: Room for removal of contaminated personal protective equipment (PPE).
5. Decontamination Shower Facility: That facility that encompasses a clean clothing storage room, and a contaminated clothing storage and disposal rooms, with a shower facility in between.
6. Eight-Hour Time Weighted Average (TWA): Airborne concentration of lead to which an employee is exposed, averaged over an 8 hour workday as indicated in 29 CFR 1926.62.
7. High Efficiency Particulate Air (HEPA) Filter Equipment: HEPA filtered vacuuming equipment with a UL 586 filter system capable of collecting and retaining lead-contaminated paint dust. A high efficiency particulate filter means 99.97 percent efficient against 0.3 micron or larger size particles.
8. Lead: Metallic lead, inorganic lead compounds, and organic lead soaps.
9. Lead-Based Paint (LBP): Paint or other surface coating that contains lead in excess of 1.0 milligrams per centimeter squared or 0.5 percent by weight.
10. Lead-Based Paint Hazard (LBP Hazard): Any condition that causes exposure to lead from lead-contaminated dust, lead-contaminated soil, lead-based paint that is deteriorated or present in accessible surfaces, friction surfaces, or impact surfaces that would result in adverse human health effects.
11. Lead-Containing Paint (LCP): Lead-based paint or other similar surface coating containing lead or lead compound in excess of 0.06 percent by weight of the total nonvolatile content of the paint.
12. Lead Control Area: An enclosed area or structure, constructed as a temporary containment equipped with HEPA filtered local exhaust, which prevents the spread of lead dust, paint chips, or debris existing as a condition of lead-based paint removal operations. The lead control area is also isolated by physical boundaries to prevent unauthorized entry of personnel.
13. Lead Permissible Exposure Limit (PEL): Fifty micrograms per cubic meter of air as an 8 hour time weighted average as determined by 29 CFR 1926.62. If an employee is exposed for more than eight hours in a work day, the PEL shall be determined by the following formula:

    PEL (micrograms/cubic meter of air) = 400/No. hrs. worked per day.
14. Personal Sampling: Sampling of airborne lead concentrations within the breathing zone of an employee to determine the 8 hour time weighted average concentration in accordance with 29 CFR 1926.62. Samples shall be representative of the employees' work tasks. Breathing zone shall be considered an area within a hemisphere, forward of the shoulders, with a radius of 6 to 9 inches (150 to 225 mm) and centered at the nose or mouth of an employee.

15. Physical Boundary: Area physically roped or partitioned off around an enclosed lead control area to limit unauthorized entry of personnel. As used in this section, "inside boundary" shall mean the same as "outside lead control area but inside boundary."

C. Submittals: Submit the following:
1. Product Data:
   a. Vacuum filters
   b. Respirators
2. Test Reports
   a. Sampling results
   b. Assessment data report
3. Certificates
   a. Qualifications of CP
   b. Testing laboratory</SUB> qualifications
   c. Third party consultant qualifications
   d. Lead-Based Paint/Lead-Containing Paint Removal Plan including CP approval (signature, date, and certification number)
   e. Rental equipment notification
   f. Respiratory protection program
   g. Hazard communication program
   h. EPA approved hazardous waste treatment or disposal facility for lead disposal
   i. Hazardous waste management plan
   j. Vacuum filters
4. Manufacturer's Instructions
   a. Chemicals and equipment
   b. Materials
   c. Material safety data sheets for all chemicals
5. Closeout Submittals
   a. Completed and signed hazardous waste manifest from treatment or disposal facility
   b. Certification of medical examinations
   c. Employee training certification

D. Qualifications Of CP
1. Submit name, address, and telephone number of the CP selected to perform responsibilities specified in paragraph entitled "Competent Person (CP) Responsibilities." Provide previous experience of the CP. Submit proper documentation that the CP is trained and licensed and certified in accordance with Federal, State, and local laws.

E. Third Party Consultant Qualifications
1. Submit the name, address, and telephone number of the third party consultant selected to perform the wipe sampling for determining concentrations of lead in dust or soil sampling. Submit proper documentation that the consultant is trained and certified as an inspector technician or inspector/risk assessor by the USEPA authorized State (or local) certification and accreditation program.

F. Testing Laboratory
1. Submit the name, address, and telephone number of the testing laboratory selected to perform the air and wipe and soil sampling, testing, and reporting of airborne concentrations of lead. Use a laboratory accredited under the EPA National Lead Laboratory Accreditation Program (NLLAP) by either the American Association for Laboratory Accreditation (A2LA) or the American Industrial Hygiene Association (AIHA) and that is successfully participating in the Environmental Lead Proficiency Analytical Testing (ELPAT) program to perform sample analysis.

G. Lead-Based Paint/Lead-Containing Paint Removal Plan (LBP/LCPRP)

1. Submit a detailed job-specific plan of the work procedures to be used in the removal of LBP/LCP. The plan shall include a sketch showing the location, size, and details of lead control areas, location and details of decontamination facilities, viewing ports, and mechanical ventilation system. Include in the plan, eating, drinking, smoking and sanitary procedures, interface of trades, sequencing of lead related work, collected waste water and paint debris disposal plan, air sampling plan, respirators, personal protective equipment, and a detailed description of the method of containment of the operation to ensure that airborne lead concentrations of 30 micrograms per cubic meter of air and baseline lead dust/soil concentrations are not reached or exceeded outside of the lead control area. Include site preparation and cleanup procedures. Include occupational and environmental sampling, training and strategy, sampling methodology, frequency, duration of sampling, and qualifications of sampling personnel in the air sampling portion of the plan.

H. Occupational And Environmental Sampling Results
1. Submit occupational and environmental sampling results to the the Owner within three working days of collection, signed by the testing laboratory responsible official, the employee that performed the sampling, and the CP.
   a. The sampling results shall represent each job classification, or if working conditions are similar to previous jobs by the same employer, provide previously collected exposure data that can be used to estimate worker exposures in accordance with 29 CFR 1926.62. The data shall represent the worker's regular daily exposure to lead.
   b. Submit worker exposure data conducted during the task based trigger operations of 29 CFR 1926.62.
   c. The initial monitoring shall determine the requirements for further monitoring and the need to fully implement the control and protective requirements including the compliance program (LBP/LCP) in accordance with 29 CFR 1926.62.

I. Occupational And Environmental Assessment Data Report:
1. Some LBP/LCP removal work may not require full implementation of the requirements of 29 CFR 1926.62. Based on the experience of the Contractor and/or the use of a specific process or method for performing the work, the Contractor may be able to provide historic data (previous 12 months) to demonstrate that airborne exposures are controlled below the action level. Such methods or controls shall be fully presented in the LBP/LCPRP. To reduce the full implementation of 29 CFR 1926.62, the Contractor shall provide documentation in an Assessment Data Report.
2. Submit occupational and environmental assessment report to the the Owner prior to start of work, signed by the testing laboratory responsible official, and the CP.
   a. Submit a report that supports the determination regarding the reduction of the need to fully implement the requirements of 29 CFR 1926.62 and supporting the LBP/LCP. The exposure assessment shall represent each job classification, or if working conditions are similar to previous jobs by the same employer, provide previously collected exposure data that can be used to estimate worker exposures in accordance with 29 CFR 1926.62. The data shall represent the worker's regular daily exposure to lead for stated work.
   b. Submit worker exposure data conducted during the task based trigger operations of 29 CFR 1926.62 with a complete process description in supporting a negative assessment.
   c. The initial assessment shall determine the requirement for further monitoring and the need to fully implement the control and protective requirements including the compliance program (LBP/LCPRP) in accordance with 29 CFR 1926.62.

J. Quality Assurance
1. Medical Examinations: Initial medical surveillance as required by 29 CFR 1926.62 shall be made available to all employees exposed to lead at any time (1 day) above the action level. Full medical surveillance shall be made available to all employees on an annual basis who are or may be exposed to lead in excess of the action level for more than 30 days a year or as required by 29 CFR 1926.62. Adequate records shall show that employees meet the medical surveillance requirements of 29 CFR 1926.33, 29 CFR 1926.62, and 29 CFR 1926.103.

a. Medical Records: Maintain complete and accurate medical records of employees for a period of at least 30 years or for the duration of employment plus 30 years, whichever is longer.
b. Medical Surveillance: Provide medical surveillance to all personnel exposed to lead as indicated in 29 CFR 1926.62.

2. Competent Person (CP) Responsibilities
   a. Certify training as meeting all federal, State, and local requirements.
   b. Review and approve lead-based paint/lead-containing paint removal plan for conformance to the applicable referenced standards.
   c. Continuously inspect lead-based paint removal work for conformance with the approved plan.
   d. Perform air and wipe sampling.
   e. Ensure work is performed in strict accordance with specifications at all times.
   f. Control work to prevent hazardous exposure to human beings and to the environment at all times.
   g. Certify the conditions of the work as called for elsewhere in this specification.
3. Training: Train each employee performing paint removal, disposal, and air sampling operations prior to the time of initial job assignment and annually thereafter, in accordance with 29 CFR 1926.21, 29 CFR 1926.62, and State and local regulations.
   a. Training Certification: Submit a certificate for each employee, signed and dated by the approved training source, stating that the employee has received the required lead training.
4. Respiratory Protection Program
   a. Furnish each employee required to wear a negative pressure respirator or other appropriate type with a respirator fit test at the time of initial fitting and at least annually thereafter as required by 29 CFR 1926.62.
   b. Establish and implement a respiratory protection program as required by ANSI Z88.2, 29 CFR 1926.103, 29 CFR 1926.62, and 29 CFR 1926.55.
5. Hazard Communication Program: Establish and implement a Hazard Communication Program as required by 29 CFR 1926.59.
6. Hazardous Waste Management: The Hazardous Waste Management Plan shall comply with applicable requirements of federal, State, and local hazardous waste regulations and address:
   a. Identification and classification of hazardous wastes associated with the work.
   b. Estimated quantities of wastes to be generated and disposed of.
   c. Names and qualifications of each contractor that will be transporting, storing, treating, and disposing of the wastes. Include the facility location and operator and a 24-hour point of contact. Furnish two copies of EPA, or State and local hazardous waste permit applications or permits or manifests, as required, and EPA Identification numbers.
   d. Names and qualifications (experience and training) of personnel who will be working on-site with hazardous wastes.
   e. List of waste handling equipment to be used in performing the work, to include cleaning, volume reduction, and transport equipment.
   f. Spill prevention, containment, and cleanup contingency measures including a health and safety plan to be implemented in accordance with 29 CFR 1926.65.
   g. Work plan and schedule for waste containment, removal and disposal. Wastes shall be cleaned up and containerized daily.
   h. Unit cost for hazardous waste disposal according to this plan.
7. Environmental, Safety and Health Compliance: In addition to the detailed requirements of this specification, comply with laws, ordinances, rules, and regulations of Federal, State, and local authorities regarding removing, handling, storing, transporting, and disposing of lead waste materials. Comply with the applicable requirements of the current issue of 29 CFR 1926.62. Submit matters regarding interpretation of standards to the the Owner for resolution before starting work. Where specification requirements and the referenced documents vary, the most stringent requirement shall apply.

8. Pre-Construction Conference: Along with the CP, meet with the the Owner to discuss in detail the hazardous waste management plan and the lead-based paint/lead-containing paint removal plan, including work procedures and precautions for the removal plan.

K. Equipment
1. Respirators: Furnish appropriate respirators approved by the National Institute for Occupational Safety and Health (NIOSH), Department of Health and Human Services, for use in atmospheres containing lead dust. Respirators shall comply with the requirements of 29 CFR 1926.62.
2. Special Protective Clothing: Furnish personnel who will be exposed to lead-contaminated dust with proper disposable uncontaminated, reusable protective whole body clothing, head covering, gloves, and foot coverings as required by 29 CFR 1926.62. Furnish proper disposable plastic or rubber gloves to protect hands. Reduce the level of protection only after obtaining approval from the CP.
3. Rental Equipment Notification: If rental equipment is to be used during lead-based paint handling and disposal, notify the rental agency in writing concerning the intended use of the equipment. Furnish a copy of the written notification to the the Owner.
4. Vacuum Filters: UL 586 labeled HEPA filters.
5. Equipment for Owner's Personnel: Furnish the the Owner with two complete sets of personal protective equipment (PPE) daily, as required herein, for entry into and inspection of the paint removal work within the lead controlled area. Personal protective equipment shall include disposable whole body covering, including appropriate foot, head, and hand protection. PPE shall remain the property of the Contractor. Respiratory protection for the the Owner will be provided by the Owner.

L. Removal
1. Title to Materials: Materials resulting from demolition work, except as specified otherwise, shall become the property of the Contractor and shall be disposed of in accordance with Division 01 Section(s) "Selective Demolition" OR Division 02 Section(s) "Building Demolition", except as specified herein.

1.2 PRODUCT

A. Chemicals
1. Submit applicable Material Safety Data Sheets for all chemicals used in paint removal work. Use the least toxic product approved by the the Owner.

B. Materials
1. The soluble metal content and the total metal content shall not exceed values which would cause a material to be classified as a hazardous waste.

1.3 EXECUTION

A. Protection
1. Notification: Notify the the Owner 20 days prior to the start of any paint removal work.
2. Lead Control Area Requirements
   a. If LBP will be removed by means which will not likely create airborne, lead-containing dust (such as careful wet scraping or chemical stripping), establish a lead control area by situating critical barriers and physical boundaries around the area or structure where LBP/LCP removal operations will be performed.
   b. If removal practice will create airborne, lead-containing dust (such as sanding, abrasive blasting, thermal cutting, demolition, or needle gun use), utilize full containment procedures - Contain removal operations by the use of critical barriers and HEPA filtered exhaust **OR** a negative pressure enclosure system with decontamination facilities and with HEPA filtered exhaust if required by the CP, **as directed**. For containment areas larger than 1,000

square feet (100 square meters) install a minimum of two 18 inch (450 mm) square viewing ports. Locate ports to provide a view of the required work from the exterior of the enclosed contaminated area. Glaze ports with laminated safety glass.

3. Protection of Existing Work to Remain: Perform paint removal work without damage or contamination of adjacent areas. Where existing work is damaged or contaminated, restore work to its original condition or better.
4. Boundary Requirements: Provide physical boundaries around the lead control area by roping off the area designated in the work plan or providing curtains, portable partitions or other enclosures to ensure that airborne concentrations of lead will not reach 30 micrograms per cubic meter of air outside of the lead control area.
   a. Physical Boundary: Provide physical boundaries around the lead control area by roping off the area designated in the work plan or providing curtains, portable partitions or other enclosures to ensure that airborne concentrations of lead will not reach 30 micrograms per cubic meter of air outside of the lead control area.
   b. Warning Signs: Provide warning signs at approaches to lead control areas. Locate signs at such a distance that personnel may read the sign and take the necessary precautions before entering the area. Signs shall comply with the requirements of 29 CFR 1926.62.
5. Furnishings:
   a. The Owner will remove furniture and equipment from the building before lead-based paint removal work begins.

      OR

      Furniture and equipment will remain in the building. Protect and cover furnishings or remove furnishings from the work area and store in a location approved by the the Owner.

      OR

      Existing furniture and equipment is lead contaminated, decontaminate, dispose of as lead contaminated waste.
6. Heating, Ventilating and Air Conditioning (HVAC) Systems: Shut down, lock out, and isolate HVAC systems that supply, exhaust, or pass through the lead control areas. Seal intake and exhaust vents in the lead control area with 6 mil (0.15 mm) plastic sheet and tape. Seal seams in HVAC components that pass through the lead control area. Provide temporary HVAC system for areas in which HVAC has been shut down outside the lead control area.
7. Decontamination Shower Facility: Provide clean and contaminated change rooms and shower facilities in accordance with this specification and 29 CFR 1926.62.
8. Eye Wash Station: Where eyes may be exposed to injurious corrosive materials, suitable facilities for quick drenching or flushing of the eyes shall be provided within the work area.
9. Mechanical Ventilation System
   a. Use adequate ventilation to control personnel exposure to lead in accordance with 29 CFR 1926.62.
   b. To the extent feasible, use fixed local exhaust ventilation connected to HEPA filters or other collection systems, approved by the CP. Local exhaust ventilation systems shall be designed, constructed, installed, and maintained in accordance with ANSI Z9.2.
   c. Vent local exhaust outside the building only and away from building ventilation intakes.
   d. Use locally exhausted, power actuated, paint removal tools.
10. Personnel Protection: Personnel shall wear and use protective clothing and equipment as specified herein. Eating, smoking, or drinking or application of cosmetics is not permitted in the lead control area. No one will be permitted in the lead control area unless they have been appropriately trained and provided with protective equipment.

B. Work Procedures: Perform removal of lead-based paint in accordance with approved lead-based paint/lead-containing paint removal plan. Use procedures and equipment required to limit occupational and environmental exposure to lead when lead-based paint is removed in accordance with 29 CFR 1926.62, except as specified herein. Dispose of removed paint chips and associated waste in compliance with Environmental Protection Agency (EPA), federal, State, and local requirements.

1. Personnel Exiting Procedures: Whenever personnel exit the lead-controlled area, they shall perform the following procedures and shall not leave the work place wearing any clothing or equipment worn during the work day:
   a. Vacuum themselves off.
   b. Remove protective clothing in the contaminated change room, and place them in an approved impermeable disposal bag.
   c. Shower **OR** Wash hands and face at the site, **as directed**, don appropriate disposable or uncontaminated reusable clothing; move to an appropriate facility; shower.
   d. Change to clean clothes prior to leaving the physical boundary designated around the lead control area.
2. Air and Wipe Sampling
   a. Air sample for lead in accordance with 29 CFR 1926.62 and as specified herein. Air and wipe sampling shall be directed or performed by the CP.
      1) The CP shall be on the job site directing the air and non-clearance wipe sampling and inspecting the lead-based paint removal work to ensure that the requirements of the contract have been satisfied during the entire lead-based paint removal operation.
      2) Collect personal air samples on employees who are anticipated to have the greatest risk of exposure as determined by the CP. In addition, collect air samples on at least 25 percent of the work crew or a minimum of two employees, whichever is greater, during each work shift.
      3) Submit results of air samples, signed by the CP, within 72 hours after the air samples are taken. Notify the the Owner immediately of exposure to lead at or in excess of the action level of 30 micrograms per cubic meter of air outside of the lead control area.
      4) For high profile, sensitive work such as present in family housing, child care facilities, administrative buildings, kitchens, barracks, etc., surface dust sampling to determine clearance (i.e., that the work has not contaminated surfaces within and adjacent to the control area) should be performed by a third party to reduce a conflict of interest. Samples must be conducted by an individual not paid or employed or otherwise compensated by the LBP/LCP removal Contractor. State or local regulations may require third party testing if the LBP/LCP removal operation is considered a lead hazard reduction activity.
      5) Before any work begins, collect and analyze baseline or soil wipe samples in accordance with methods defined in federal, State, and local standards inside and outside of the physical boundary to assess the degree of dust contamination in the facility prior to lead-based paint removal.
   b. Air Sampling During Paint Removal Work: Conduct area air sampling daily, on each shift in which lead-based paint removal operations are performed, in areas immediately adjacent to the lead control area. Sufficient area monitoring shall be conducted to ensure unprotected personnel are not exposed at or above 30 micrograms per cubic meter of air. If 30 micrograms per cubic meter of air is reached or exceeded, stop work, correct the conditions(s) causing the increased levels. Notify the the Owner immediately. Determine if condition(s) require any further change in work methods. Removal work shall resume only after approval is given by the CP and the the Owner. For outdoor operations, at least one sample on each shift shall be taken on the downwind side of the lead control area.
3. Lead-Based Paint Removal
   a. Manual or power sanding of interior and exterior surfaces is not permitted. Provide methodology for removing LBP in work plan. Remove paint within the areas designated on the drawings in order to completely expose the substrate. Take whatever precautions necessary to minimize damage to the underlying substrate.
   b. Avoid flash rusting or deterioration of the substrate. Provide surface preparations for painting in accord with Division 07.
   c. Provide methodology for removing LBP/LCP removal processes to minimize contamination of work areas outside the control area with lead-contaminated dust or other lead-contaminated debris/waste and to ensure that unprotected personnel are not exposed to

hazardous concentrations of lead. Describe this LBP/LCP removal process in the LBP/LCPRP.

d. Indoor Lead Paint Removal: Perform manual **OR** mechanical **OR** thermal **OR** chemical, **as directed**, paint removal in lead control areas using enclosures, barriers, or containments and powered locally exhausted paint removal tools. Collect residue and/or debris for disposal in accordance with federal, State, and local requirements.

e. Outdoor Lead Paint Removal: Perform outdoor removal as indicated in federal, State, and local regulations and in the LBP/CPRP. The worksite preparation (barriers or containments) shall be job dependent and presented in the LBP/LCPRP.

f. Sampling After Paint Removal: After the visual inspection, conduct soil sampling if bare soil is present during external removal operations and collect air samples inside and outside the lead control area to determine the airborne levels of lead inside and outside the work area. Collect wipe samples according to the HUD protocol contained in HUD Guidelines to determine the lead content of settled dust and dirt in micrograms per square foot (square meter) of surface area and parts per million (ppm) or micrograms per gram (µg/g) for soil.

4. Cleanup and Disposal

a. Cleanup: Maintain surfaces of the lead control area free of accumulations of paint chips and dust. Restrict the spread of dust and debris; keep waste from being distributed over the work area. Do not dry sweep or use compressed air to clean up the area. At the end of each shift and when the paint removal operation has been completed, clean the area of visible lead paint contamination by vacuuming with a HEPA filtered vacuum cleaner, wet mopping the area and wet wiping the area as indicated by the CP. Reclean areas showing dust or residual paint chips or debris. After visible dust, chips and debris is removed, wet wipe and HEPA vacuum all surfaces in the work area. If adjacent areas become contaminated at any time during the work, clean, visually inspect, and then wipe sample all contaminated areas. The CP shall then certify in writing that the area has been cleaned of lead contamination before restarting work.

b. Clearance Certification

1) The CP shall certify in writing that the final air samples collected inside and outside the lead control area are less than 30 micrograms per cubic meter of air; the respiratory protection used for the employees was adequate; the work procedures were performed in accordance with 29 CFR 1926.62 and 40 CFR 745; and that there were no visible accumulations of material and dust containing lead left in the work site. Do not remove the lead control area or roped off boundary and warning signs prior to the the Owner's acknowledgement of receipt of the CP certification.

2) A third party consultant shall certify surface wipe sample results collected inside and outside the work area are less than 100 micrograms per square foot (0.1 square meter) on uncarpeted floors, less than 500 micrograms per square foot (0.1 square meter) on interior window sills and less than 800 micrograms per square foot (0.1 square meter) on window troughs **OR** not significantly greater than the initial surface loading determined prior to work, **as directed**.

3) For exterior paint removal work, soil samples taken at the exterior of the work site shall be sued to determine if soil lead levels had increased at a statistically significant level (significant at the 95 percent confidence limit) from the soil lead levels prior to the work. If soil lead levels do show a statistically significant increase above any applicable Federal or State standard for lead in soil, the soil shall be remediated back to the pre-work level.

c. Testing of Lead-Based Paint Residue and Used Abrasive: Test paint residue and used abrasive in accordance with 40 CFR 261 for hazardous waste.

d. Disposal

1) Collect lead-contaminated waste, scrap, debris, bags, containers, equipment, and lead-contaminated clothing which may produce airborne concentrations of lead particles. Label the containers in accordance with 29 CFR 1926.62 and 40 CFR

261. Dispose of lead-contaminated waste material at an EPA or State approved hazardous waste treatment, storage, or disposal facility off Owner's property.

2) Store waste materials in U.S. Department of Transportation (49 CFR 178) approved 55 gallon (208 liter) drums. Properly label each drum to identify the type of waste (49 CFR 172) and the date the drum was filled. The the Owner or an authorized representative will assign an area for interim storage of waste-containing drums. Do not store hazardous waste drums in interim storage longer than 90 calendar days from the date affixed to each drum.

3) Handle, store, transport, and dispose lead or lead-contaminated waste in accordance with 40 CFR 260, 40 CFR 261, 40 CFR 262, 40 CFR 263, 40 CFR 264, and 40 CFR 265. Comply with land disposal restriction notification requirements as required by 40 CFR 268.

4) All material, whether hazardous or non-hazardous shall be disposed in accordance with laws and provisions and Federal, State, or local regulations. Ensure waste is properly characterized. The result of each waste characterization (TCLP for RCRA materials) will dictate disposal requirements.

5. Disposal Documentation: Submit written evidence that the hazardous waste treatment, storage, or disposal facility (TSD) is approved for lead disposal by the EPA and State or local regulatory agencies. Submit one copy of the completed manifest, signed and dated by the initial transporter in accordance with 40 CFR 262.

6. Payment for Hazardous Waste: Payment for disposal of hazardous waste will not be made until a signed copy of the manifest from the treatment or disposal facility certifying the amount of lead-containing materials delivered is returned and a copy is furnished to the Owner.

END OF SECTION 13285

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SECTION 13285a - LEAD PAINT RELATED ABATEMENT PROCEDURES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for lead paint related abatement procedures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. General Provisions

1. The site of this work will be occupied while work is being done. Perform the abatement work with the least inconvenience to the residents.
2. Take all necessary precautions to protect the property of the the Owner and its residents. Damaged property shall be repaired and restored to its original condition. If the damage is beyond repair, the Contractor shall replace it with new materials to match existing, at the Contractor's expense.
3. Hazardous waste generated during the abatement process (including lead-base paint) when carted away from the developments shall not be transferred from one vehicle to another except at a licensed transfer station.
4. Develop a work plan to be performed as requested by the the Owner. The detailed plan shall include sequencing of abatement work in a manner that will be least disruptive to the normal use of the non-work areas in the building. The plan should also include emergency procedures in case of fire.
5. The Contractor shall include all supplementary miscellaneous items not specified but implied or required in order to complete the work.
6. Workmanship required in the execution of the work herein specified shall be of good quality and subject to the approval of the the Owner.
7. Make in a timely fashion all applicable and necessary notifications to relevant Federal, State and Local authorities. The Contractor shall indemnify the the Owner and the the Owner's representative from, and pay all claims resulting from failure to adhere to these provisions.
8. the Owner may retain an independent Monitoring Contractor to monitor the abatement contract and conduct all wipe sampling and clearance tests.
9. Contractor performing lead-based paint abatement or renovation activities involving lead-based paint shall be a Certified Lead Abatement Contractor and shall ensure that supervisors and workers are trained and certified by U.S. EPA approved state program or equivalent, to perform lead paint removal operations.
10. Establish and implement a Chemical Hazard Communication Program as required by OSHA regulations 29 CFR 1926.59.
11. Provide workers with a comprehensive medical examination as required by OSHA regulations 29 CFR 1926.62 before exposure to lead contaminated dust. The medical examination shall be conducted to approve use of appropriate respirators and shall include biological monitoring NIOSH/MSHA approved respirators shall be utilized.
12. For employees required to wear a negative pressure respirators: conduct a respirator fit test at the time of initial fitting and at least once every six (6) months thereafter as required by OSHA regulations 29 CFR 1926.62.
13. Determine if any worker will be exposed to lead at or above the action level in accordance with OSHA regulation 29 CFR 1926.62 and 29 CFR 1910.1025. Conduct an exposure assessment to identify the level of exposure a worker would be subjected to without respiratory protection. Assess the exposure level by obtaining personal monitoring samples representative of a full shift of at least an 8-hour TWA.
14. Furnish appropriate respirators approved by NIOSH/MSHA for use in atmospheres containing lead aerosols. Instruct workers in all aspects of respiratory protection. Maintain an adequate supply of HEPA filter elements and spare parts on site for all types of respirators in use.

15. For manual demolition, scraping, sanding, use of heat gun or power tool paint removal with HEPA collection systems, workers shall minimally use the half-mask negative pressure respirator with high efficiency filters (for airborne concentrations not in excess of 500µg/m³).
16. Ensure that work area preparation, work practices, and clean-up procedures comply with these specifications and applicable Federal, State and Local regulations.
17. Notify all applicable agencies five days prior to the date the abatement will begin and provide evidence of notifications to the the Owner at the pre-start meeting.

C. Submissions
1. Within ten (10) consecutive calendar days calculated from the date of the the Owner's Job Order, the Contractor shall tender all required submissions. Six (6) sets of each submission are required. Where physical samples are required two (2) physical samples shall be submitted for each item. In general, items shall include but not be restricted to the following:
   a. Paint remover - corner cutter/Vac-Pac System by Pentek Inc; Decontamination Products Division 1026 Fourth Avenue, Corapolis, PA. 15108. Telephone No. (412) 262-0725 or approved equal.
   b. Description of removal method to be used on each substrate condition including manufacturer's operating instructions and recommendation for equipment usage.
   c. Copies of current training certificates of Staff to be assigned to the contract.
   d. List of three previous lead abatement jobs performed successfully by Contractor and name, address, and telephone number of contact person for verification.
2. In the event that all or any portion of the submitted material is rejected by the the Owner, the Contractor shall tender new submissions. All submissions returned for corrections shall be resubmitted with the required corrections within ten(10) consecutive calendar days calculated from the date of rejection, until final submissions are obtained that require no further correction. In no event shall the Contractor be permitted to tender submissions hereunder beyond twenty (20) days from the the Owner's Job Order, unless duly extended in writing by the the Owner.
3. No work shall begin, nor shall the materials be ordered or delivered to the site until final approval of all submissions.

D. Applicable Regulations
1. 24 CFR Part 35
2. HUD ”Guidelines For the Evaluation and Control of Lead-Based Paint Hazards in Housing”
3. Abatement work shall also be in accordance with applicable regulations of the Environmental Protection Agency (EPA), Occupational Safety & Health Agency (OSHA) and any State or Local LBP standards. Where there is a conflict between Federal, State or Local regulations, the more stringent requirement shall prevail.
4. OSHA Standards
   a. 29 CFR 1926.20 General safety and health provisions;
   b. 29 CFR 1926.21 Safety training and education;
   c. 29 CFR 1925.25 Housekeeping;
   d. 29 CFR 1926-28 Personal protective equipment;
   e. 29 CFR 1926.51(f) Washing facilities;
   f. 29 CFR 1926.55 Gases, vapors, fumes, dusts, and mists;
   g. 29 CFR 1926.57 Ventilation
   h. 29 CFR 1926.59 Hazardous Communication Standards;
   i. 29 CFR 1926.103 Respiratory protection, and
   j. 29 CFR 1926.62 Lead in Construction
5. The Contractor must comply with all applicable requirements of the Resource Conservation & Recovery Act (RCRA) of 1976 as amended in 1980 and 1984 by the Hazardous & Solid Waste Amendments (HSWA).
6. These Specifications refer to many requirements found in the preceding references but in no way is it intended to cite or reiterate all provisions therein or elsewhere. It is the Contractor's responsibility to obtain a copy, and know, understand and abide by all such regulations, guidelines and common practices.

1.2 PRODUCTS – (not used)

1.3 EXECUTION

A. Abatement

1. Have risk assessment or paint inspection performed by certified risk assessor or a certified inspector technician who is independent of the abatement contractor.
2. Develop a site specific lead hazard control plan, reviewed and signed by an asbestos consultant (LAC) who is licensed in the State in which the work is to be performed, and submit for review and approval to the the Owner.
3. Obtain any necessary building or waste permits, notify local authorities as required by applicable codes and laws.
4. Select specific building component replacement items, enclosure materials, paint removal equipment and/or chemicals, tools, and cleaning supplies. Consider waste management and historical preservation implications of selected treatment.
5. Develop project specific specifications.
6. Schedule other work so that leaded surfaces are not inadvertently disturbed and unprotected workers are not place at risk. Include time for clearance examinations and laboratory dust sample analysis in the scheduling process.
7. Select a certified abatement subcontractor.
8. Conduct a pre-construction conference to ensure that the subcontractor fully understands the work involved.
9. Notify residents of the dwelling and adjacent dwellings of the work and date it will begin. Coordinate this with the the Owner.
10. Correct any existing conditions that could impede the abatement work (i.e. trash removal, structural deficiencies).
11. Post warning signs and restrict entry to work area to authorized personnel. Implement worksite preparation procedures.
    a. Place proper warning signs required by OSHA regulations at all entrances to the work area. Signage shall be minimum of 12" x 20" and shall state the following:

WARNING
LEAD WORK AREA
POISON
NO SMOKING OR EATING

12. Coordinate test, pilot or sample portion approach to the project with the Owner.
13. Shut-down forced air heating, ventilation and air conditioning systems and cover all vents, diffusers, windows etc., with a single layer six-mil polyethylene sheet secured with duct tape. Exceptions shall be for minor disturbances of area less than 2 square feet and where if vents, diffusers, and windows are more than 5 feet away from surface being disturbed, they need not be covered.
14. Collect preabatement soil samples, which may not have to be analyzed until post abatement soil samples have been collected, analyzed, and compared to clearance standards. If postabatement soil levels are below applicable limits, the preabatement samples need not be analyzed.
15. Cover entrances to the work area with a single layer of 6 mil polyethylene sheets taped to the top and weighted at bottom.
16. Rig a containment non-flammable polyethylene sheet underneath the work area. This containment method should catch all stripped paint for proper disposal.
17. Execute abatement work.
18. Avoid spreading dust and debris outside the work area.
19. Store all waste in a secure area and make sure it is properly labeled with an accumulation start date.
20. Conduct daily and final cleanup.
21. Execute waste disposal procedures.

22. Maintain appropriate records.

B. Paint Removal

1. Do not use the following prohibited paint removal methods:
   a. Dry scraping or sanding (except for limited areas)
   b. Use of heat gun over 1,100°F
   c. Open flame burning or torching
   d. Machine sanding or grinding without HEPA vacuum exhaust tool
   e. Abrasive blasting or sandblasting without HEPA vacuum exhaust tool
   f. Uncontained hydro blasting or high-pressure wash
   g. Use of chemical strippers containing Methylene chloride.
2. Select the appropriate worksite preparation level.
3. For heat gun work, provide fire extinguishers in the work area and ensure that adequate electrical power is available. Use for limited areas only. Train workers to avoid gouging or abrading the substrate.
4. For mechanical removal methods, use tools equipped with HEPA exhaust capability. Be sure workers keep the shroud against the surface being treated. Vacuum blasting and needle guns should not be used on wood, plaster, drywall, or other soft substrates. Observe all manufacturers directions for the amount of vacuum airflow required.
5. For wet scraping, use a spray bottle or wet sponge attached to the scraper to keep the surface wet while scraping. Apply enough water to moisten the surface completely, but not so much that large amounts of water run onto the ground or floor. Do not moisten areas near electrical circuits.
6. For chemical paint removers, determine if the building component can be removed and stripped offsite. Offsite stripping is generally preferred to onsite paint removal. Observe all manufacturers' directions for use of paint removers.
7. For offsite stripping, determine how to remove the component. Score the edges with a knife or razor blade to minimize the damage to adjacent surfaces. Punch or tag the building component, if similar building components are also being stripped offsite (i.e. doors). This will ensure that the individual component is reinstalled in the same location. Inform the offsite paint remover that the lead-based paint component is present for shipping. Wrap the component in plastic and send to the offsite stripping location. Clean all surfaces before reinstallation and remove any lead residue by HEPA vacuuming all surfaces, cleaning with other lead-specific cleaners, or phosphate detergents, and HEPA vacuuming again.
8. For onsite paint removal, first test the product on a small area to determine its effectiveness. Chemical paint removers may not be effective or desirable on exterior, deteriorated wood surfaces, aluminum, and glass. Provide neoprene, nitrile, rubber, or polyvinyl chloride (PVC) gloves (or other type of glove recommended by the manufacture); face shields; respirators with combination filter cartridges for lead dust and organic vapors(if appropriate); and chemically resistant clothing. Be sure to select the right type of organic vapor filter cartridge, gloves, and clothing for the specific chemical being used. Portable eyewash stations capable of providing a 15-minute flow must be on-site. Apply the chemical and wait the required period of time. Securely store chemical s overnight. For caustic chemical paint removers, neutralize the surface before repainting using glacial acetic acid (not vinegar). Repaint.
9. Make sure all debris is caught in the containment sheet for proper disposal.
10. Mark and legally dispose of waste in accordance with all applicable Federal, State and Local regulations. Most wastes from paint removal projects, such as paint chips and paint remover sludge, will need to be managed as hazardous waste.
11. Conduct clean-up
12. Have a certified risk assessor or inspector technician conduct a clearance examination and provide documentation and a Statement of Lead-Based Paint Compliance.

C. Building Component Replacement

1. Prepare work area by selecting proper worksite preparation level.
2. Prepare the hazardous material building component for removal. Turn off and disconnect any electrical circuits inside or near the building component to be removed.

3. Lightly mist the component to be removed (unless electrical circuits are located nearby).
4. Score all painted seams with a sharp knife.
5. Remove any screw, nails, or other fasteners.
6. Use flat pry instrument and hammer to pry component from the substrate.
7. Remove or bend back all nails.
8. Wrap and seal all bulk components in plastic and take them to a covered truck or secured waste storage area along a pathway covered in plastic. Shovel any debris. Dispose of properly.
9. HEPA vacuum any dust or chips in the area where the component was located.
10. Conduct cleaning and clearance activities.

D. Soil and Exterior Dust Abatement

1. Determine if soil lead hazard exists. For hazard to exist, a total of at least 9 square feet of soil in a single yard or area must be bare and soil concentrations must exceed 2,000µg/gram lead for the yard or building perimeter or 400µg/gram of lead for small, high-contact play areas (pending the development of an EPA soil standard). Bare soil above these levels shall be treated by either interim controls or abatement. Soil abatement is most appropriate when levels of lead are extraordinarily high (greater than 5,000µg/gram lead) and when use patterns indicate contact frequency and exposure will be high.
2. Collect Preabatement soil samples to determine baseline levels. These samples need not be analyzed if post abatement samples are below applicable clearance levels.
3. Determine the method of soil abatement (soil removal and replacement, soil cleaning, or paving). Soil cultivation (rototilling or turning over the soil) is not permitted.
4. If paving, use a high quality concrete or asphalt. Observe normal precautions associate with traffic load weight and thermal expansion and contraction. Obtain necessary permits. Keep soil cultivation to a minimum.
5. If removing and replacing soil.
   a. Determine if waste soil will be placed in an offsite burial pit. Prepare vehicle operation and soil movement plan. Test new replacement soil (should not contain more than 200 µg/gram lead).
   b. Contact local utilities to determine location of underground utilities including water, gas, cable TV, electric, telephone, and sewer. Mark all locations to be avoided
   c. Remove fencing, if necessary to allow equipment access and define set limits with temporary fencing, signs, or yellow caution tape.
   d. Tie and protect existing trees, shrubs, and bushes.
   e. Have enough tools to avoid handling clean soil with contaminated tools.
   f. Remove soil.
   g. Clean all walkways, driveways, and street areas near abatement area.
   h. Replace soil at proper grade to allow drainage. Replacement soil should be at least 2 inches above existing grade to allow for settling.
   i. Install new soil covering (grass or sod) and maintain it through the growing season.
   j. Determine if soil waste is hazardous and manage it accordingly
   k. Conduct clean-up and clearance.
   l. Provide walk-off doormats.
   m. Maintain proper documentation.

E. Encapsulation

1. Determine if the applicable regulations aloe encapsulates to be used. Do not encapsulate the following surfaces:
   a. Friction surfaces, such as window jambs and door jambs.
   b. Surfaces that fail patch tests.
   c. Surfaces with substrates or existing coatings that have a high level of deterioration.
   d. Surfaces I which there is a known incompatibility between two existing paint layers.
   e. Surfaces that cannot support the additional weight stress of encapsulation due to existing paint thickness.
   f. Metal surfaces that are prone to rust or corrosion.
2. Conduct field tests of surfaces to be encapsulated for paint film integrity.

3. Consider special use and environmental requirements (i.e. abrasion resistance and ability to span base substrate cracks).
4. Provide to the the Owner encapsulant test data provided by the manufacturer.
5. Conduct at least one test patch on each type of building component where the encapsulant will be used. Report the results to the the Owner.
6. For both nonreinforced and reinforced coatings, use a 6” x 6” test patch area. Prepare the surface in the manner selected to complete the job. Prepared surfaces for patch testing should be at least 2” larger in each direction than the patch area.
7. For fiber-reinforced wall coverings, use 3” x 3” patch. For rigid coatings that cannot be cut with a knife, use soundness test. For all encapsulants, carry out the appropriate adhesion tests.
8. For liquid coating encapsulants, allow coating to cure, then visually examine it for wrinkling, blistering, cracking, bubbling, or other chemical reaction with the underlying paint.
9. Record results of all patch tests and provide to the the Owner.
10. Implement proper work site preparation level.
11. Repair all building components and substrates as needed (i.e. caulk cracks and repair sources of water leaks).
12. Prepare surfaces. Remove all dirt, grease, chalking paint, mildew and other surface contaminants, remnants of cleaning solutions, and loose paint. All surfaces should be deglossed, as needed.
13. Ventilate the contaminated area whenever solvents or chemicals are used.
14. During encapsulant application or installation, monitor temperature and humidity. For liquid coatings monitor coating thickness to ensure that the encapsulant manufacturer’s installation/application specifications are followed.
15. Conduct clean up and clearance.
16. Provide the the Owner information on how to care for the encapsulation system properly.
17. Maintain records on the exact detailed locations of encapsulant applications, patch test specifications and results, product name, subcontractor, date of application, a copy of the product label and material Data Safety sheet (MSDS) for the product and provide to the the Owner.

F. Enclosure
1. Stamp, label or stencil all lead-based painted surfaces that will be enclosed with a warning approximately every 2 feet both horizontally and vertically on all components. The Warning shall read “**Danger Lead-Based Paint**”. Deteriorated paint should not be removed from the surface to be enclosed.
2. Select the proper worksite preparation level.
3. Attach a durable drawing to the utility room closet showing where lead-based paint has been enclosed in the dwelling.
4. An independent inspector or technician or risk assessor should evaluate the integrity of the enclosure.
5. Repair any unsound substrates and structural members that will support the enclosure, if necessary.
6. Utilize appropriate enclosure material (drywall or fiberboard, wood paneling, laminated products, ridged tile and brick veneers, vinyl, aluminum m, or plywood).
7. Install extension rings for all electrical switches and outlets that will penetrate the enclosure.
8. If enclosing floors, remove all dirt with a HEPA vacuum to avoid small lumps in the new flooring.
9. Seal and back-caulk all seams and joints. Back-caulk means applying caulk to the underside of the enclosure.
10. When installing enclosure directly to painted surfaces, use adhesive and then anchor with mechanical fasteners (screws or nails).
11. Conduct clean up and clearance activities.
12. Maintain proper records and submit a Statement of Lead-Based Paint Compliance.

G. Final Cleaning Procedures
1. Use the following step-by-step procedures

a. Assign responsibilities to specific workers for cleaning and for maintaining the cleaning equipment.
b. Have sufficient cleaning equipment and supplies before beginning work.
c. If contamination is extensive, conduct precleaning of the dwelling unit.
d. Conduct ongoing cleaning during the job, including regular removal of large and small debris and dust. Decontamination of all tools, equipment and worker protection gear is required before it leaves contaminated areas. Electrical equipment should be wiped and high-efficiency particulate air (HEPA) vacuumed, not wetted down, to minimize electrocution hazards.
e. Schedule sufficient time (usually 30 minutes to an hour) for complete daily cleaning, starting at the same time near the end of every workday after lead hazard control activity has stopped.
f. For final cleaning, wait at least 1 hour after active lead hazard control activity has ceased to let dust particles settle.
g. Use a vacuum cleaner equipped with a HEPA exhaust filter. HEPA vacuum all surfaces in the room (ceilings, walls, trim, and floors). Start with the ceiling and work down, moving toward the entry door. Completely clean each room before moving on.
h. Wash all surfaces with lead-specific detergent, high-phosphate detergent, or other suitable cleaning agent to dislodge any ground-in contamination, then rinse. Change the cleaning solution after every room is cleaned.
i. Repeat step g above. To meet clearance standards consistently, a HEPA vacuum, wet wash, and HEPA vacuum cycle is recommended. For interim control projects involving dust removal only, the final HEPA vacuuming step is usually not needed. Other cleaning methods are acceptable, as long as clearance criteria are met and workers are not over exposed.
j. After final cleaning perform visual examination to ensure that all surfaces requiring lead hazard control have been addressed and all visible dust and debris have been removed. Record findings and correct any incomplete work.
k. If other construction work will disturb the lead-based paint surfaces, it should be completed at this point. If those surfaces are disturbed, repeat the final cleaning step after construction work has been completed.
l. Paint and otherwise seal treated surfaces and interior floors.
m. Conduct clearance examination.
n. If clearance is not achieved, repeat final cleaning.
o. Continue clearance testing and repeated cleanings until dwelling unit achieves compliance with all clearance standards. The cost of repeated cleaning, after failure to achieve clearance is to be borne by the contractor.
p. Do not allow residents to enter work area until final cleaning is completed and clearance is established.
q. Cleaning equipment list is as follows:
    1) HEPA Vacuums
    2) Detergent
    3) Waterproof gloves
    4) Rags
    5) Sponges
    6) Mops
    7) Buckets
    8) HEPA vacuum attachments (crevice tools, beater bar for cleaning rugs)
    9) 6-mil plastic bags
    10) Debris containers
    11) Waste water containers
    12) Shovels
    13) Rakes
    14) Water-misting sprayers
    15) 6-mil polyethylene sheeting (or equivalent)

2. Order of execution for final cleaning steps should be as follows:

a. As the first stage in final cleaning, floor plastic shall be misted and swept.
b. Upper level plastic, such as on cabinets and counters should be removed first, after it has been misted and cleaned. All plastic should be carefully folded from the corners/ends to the middle to trap any remaining dust. Next remove both layers of plastic from the floor.
c. Plastic sheets used to isolate contaminated rooms from noncontaminated rooms should remain in place until after cleaning and removal of other plastic sheeting, these sheets may then be misted, cleaned and removed last.
d. Removed plastic should be placed into double 4-mil or single 6-mil plastic bags, or plastic bags with equivalent (or better) performance characteristics, which are sealed and removed from the premises. As with daily cleanings, this plastic removal process usually requires workers to use protective clothing and respirators.
e. After plastic has been removed from the contaminated area, the entire area should be cleaned using the HEPA/wet wash/HEPA cycle.

H. Waste Testing And Disposal

1. General: All materials, whether hazardous or non-hazardous shall be properly disposed of. the Owner may hire an independent Monitoring Consultant to perform TCLP test to determine which of the wastes are hazardous. Contractor shall cooperate in this test. If less than 100kg (200 lbs) or 1/2 of a 55 gallon drum of hazardous waste per month will be generated, it is considered "conditionally exempt" abatement waste, and may be managed as solid non-hazardous waste. The RCRA hazardous waste manifest is not required when shipping this waste to an offsite disposal facility.
2. Separate Abatement Waste into The Following Four Categories:
   a. Category I. Low lead waste (typically non-hazardous) e.g. Filtered personal and commercial wash water.
   b. Category II. Architectural components - (painted finish carpentry items) e.g. Doors, windows, window trim and sills, baseboards, railings, moldings. (May do a TCLP to determine if they are hazardous).
   c. Category III. Concentrated lead waste e.g. sludge from stripping, lead-base paint chip and dust, HEPA vacuum debris and filter, unfiltered wash waste, any waste included in EPA's list of hazardous waste.
   d. Category IV. Material that cannot be determined to be either hazardous or non-hazardous must be tested by TCLP.

   If the hazardous waste generated is greater than 100kg per month, dispose according to the referenced guidelines and RCRA hazardous waste management requirements including those listed below.
3. Disposal Requirements: Contact the regional EPA, state, local and all other pertinent authorities to determine lead-based paint debris disposal requirements. Comply with requirements of the Resource Conservation and Recovery Act (RCRA) and with applicable federal, state, county, or local waste requirements.
4. EPA ID Numbers: Obtain a Generator RCRA Hazardous Material ID number and coordinate this action through the State and secure any additional number as required.
5. Storage Requirements: Keep all hazardous items in a secure area or lockable container that is inaccessible to all persons other than the Contractor's personnel. Label all hazardous waste "Hazardous Waste" with the date that the Contractor began to collect the waste in that container. Keep hazardous and non-hazardous waste in separate containers. Until TCLP testing is completed, considered all items hazardous and store in a secured area or lockable container.
6. Waste Transportation: Transport hazardous waste using a RCRA/DOT/EPA certified Hazardous Waste Transporter. Submit names and qualifications of certified transporter/hauler for the Owner approval. The Contractor shall be responsible for all actions of the waste hauler as pertaining to waste removal and disposal under these procedures and all EPA, DOT and other applicable regulations.
7. Disposal Facility: Supply documents that detail the site(s) to be used for ultimate disposal. Submit documents from these sites proving that they are licensed/permitted to accept such waste and shall accept the waste proposed by the Contractor for treatment or ultimate disposal.

8. Waste Containers: Comply with EPA and DOT regulations for waste containers. Contact the state and local authorities to determine their criteria for containers. In the case of any conflict in regulations, the more stringent shall apply.
9. Emergencies: Contact local fire, police, hospitals or local emergency response teams and inform them of the type of hazardous waste activity and ask for assistance in the event of any accident. Additionally, the container shall provide the following:
   a. Keep and properly maintain a suitable fire extinguisher(s) on site.
   b. Have a immediate means of communication with the regulatory agency in the event of an emergency.
   c. Keep a list of phone numbers of regulatory agencies on site.
   d. Appoint an emergency coordinator and ensure that he is on site to supervise emergency procedures to be carried out in the event of an emergency.
   e. Keep and maintain a "right to know" manual that is in an easily accessible location and in an area that is known to all employees.
10. Transporting Waste: Provide certifications that the transporter is registered with the U.S. Department of Transportation is required by 49 CFR Part 107(a) transport hazardous waste.
   a. Provide certifications that each vehicle dedicated to haul hazardous waste has been assigned a "U.S. DOT Hazardous Material Registration Number" as required by 49 CFR Part 107.
   b. Be responsible for all other applicable permits pertaining to hauling, transport, reduction, and disposal of hazardous waste as they may apply to this project.
   c. Vehicle: Ensure that all non-hazardous waste is transported in covered vehicles to a landfill, or lined landfill, if required.
   d. Container Handling: Carefully place the containers into the truck or dumpster used for disposal. At no time shall debris or containers be thrown or dropped.
   e. Liquid Wastes: Contain and properly dispose of all liquid wastes, including lead-contaminated wash water.
   f. Containers: HEPA vacuum the exterior of all waste containers prior to removing the waste containers from the work area. Wet wipe the containers to ensure that there is no residual contamination. Then move containers out of the work area into the designated storage area.

I. Clearance
1. Clearance on all abatement projects must be done by an independent certified risk assessor or inspector technician. Follow all jurisdictional law with regard to licensure requirements for personnel conducting clearance activities.
2. Clearance step-by-step procedures are as follows:
   a. Finish the lead hazard control clean-up effort. Seal floors before clearance (if necessary).
   b. Wait 1 hour to allow any airborne dust to settle. Do not enter work area during that hour.
   c. Conduct visual examination
      1) Determine if all required work has been completed and all lead-based paint hazards have been controlled.
      2) Determine if there is visible settled dust, paint chips, or debris in the interior or around the exterior.
   d. Complete the Visual Clearance Form required by the the Owner; if all work is not completed inform the the Owner and order completion of the work and repeat cleanup, if necessary.
   e. Conduct clearance dust sampling of the floors, interior window sills, and window troughs using approved protocol.
   f. Conduct soil sampling if bare soil is present that was not sampled previously, or if exterior paint work was completed as part of the lead hazard control effort. Whenever exterior work has been don, it may be necessary to take samples from the soil that is not bare to determine if contamination has occurred. If results are above 1,000 µg/g (or 400 µg/g in high contact play area), compare the results to baseline soil sampling results to determine what additional measures are needed.
   g. Complete the Dust and Soil Sampling Clearance Form required by the the Owner.

h. Submit samples to a U.S. Environmental Protection Agency (EPA) recognized laboratory participating in the National Lead Laboratory Accreditation program (NLLAP) for analysis.

i. Interpret results by comparing them to Interim Clearance Standards as listed below:

1)	Floors	400 µg/ft2
2)	Window sills	250 µg/ft2
3)	Window Troughs	800 µg/ft2
4)	Soils (Play area with children under 6 years of age)	400 µg/gram

j. If clearance is achieved go to step N.

k. Order repeated cleanings or soil treatments if results are above applicable standards. Clean all surfaces the sample represents.

l. Continue sampling and repeated cleanings until the dwelling achieves compliance with all applicable clearance standards.

m. Complete any related construction work that does not disturb a surface with lead-based paint (all work that does disturb painted surfaces or that could generate lead dust should be completed as part of the lead hazard control effort).

n. Issue any necessary statements of lead-based paint compliance or releases and maintain appropriate records.

J. Labels

1. Use the following labels on drums used for disposal.

HAZARDOUS WASTE

FEDERAL LAW PROHIBITS IMPROPER DISPOSAL.

IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY.

GENERATOR INFORMATION:

NAME _____

ADDRESS _____ PHONE _____

CITY _____ STATE ____ ZIP _____

EPA-ID NO. / MANIFEST DOCUMENT NO. _____ / _____

ACCUMULATION START DATE _____ EPA WASTE NO. _____

HAZARDOUS WASTE, SOLID, N.O.S.

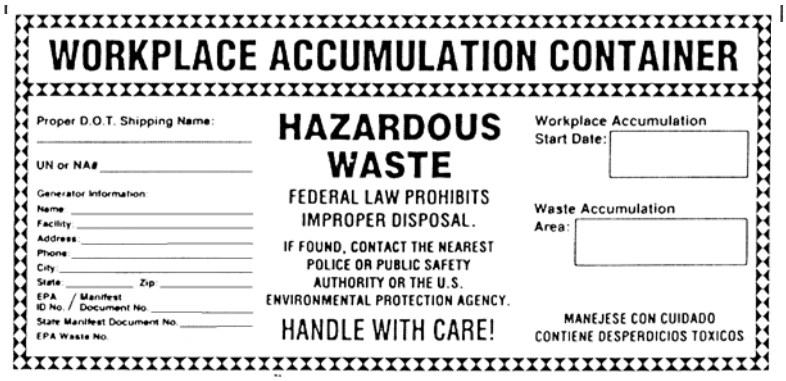
( )

NA3077

D.O.T. PROPER SHIPPING NAME AND UN OR NA NO. WITH PREFIX

HANDLE WITH CARE!

STYLE HWM12



WORKPLACE ACCUMULATION CONTAINER

Proper D.O.T. Shipping Name: _____

UN or NA# _____

Generator Information:
Name: _____
Facility: _____
Address: _____
Phone: _____
City: _____
State: _____ Zip: _____
EPA ID No. / Manifest Document No. _____
State Manifest Document No. _____
EPA Waste No.

HAZARDOUS WASTE

FEDERAL LAW PROHIBITS IMPROPER DISPOSAL.

IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY.

HANDLE WITH CARE!

Workplace Accumulation Start Date:

Waste Accumulation Area:

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K. Disposal of lead-based paint waste.

1. Follow the RCRA and HUD recommended practices as defined in the table below:

Waste Management Practices	Category I: Low Lead Waste	Category II: Architectural Components	Category III: Concentrated Lead Waste	Category IV: Other waste
RCRA Requirements	Manage as nonhazardous Waste	Depending upon knowledge or TCLP testing results, manage as solid hazardous or nonhazardous waste	If more than 100 kg/ month, manage as hazardous waste. If less than 100 kg/month manage as solid waste.	Use TCP to determine if waste is hazardous.
HUD Recommended Practices	Applicable	Applicable, if knowledge or TCLP testing indicates that it is nonhazardous.	Applicable if less than 100 kg/month otherwise subject to full RCRA regulations	Only applicable if TCLP testing shows waste is nonhazardous
Wrapped in plastic; seal all seams with tape (if acceptable to the disposal facility).	X	X	X	X
Stored in designated, secure area.	X	X	X	X
Covered During Transport	X	X	X	X
Prohibit cutting/breaking outside work area.	X	X	X	X
Cover ground with 6-mil plastic if handling outside.	X	X	X	X
Prohibit disposal in solid waste incinerators and reuse recycling for mulch	X	X	X	X
Recommended disposal in State licensed/permitted	X	X	If appropriate.	X

solid waste landfill.				

L. Safety Requirements

1. To protect the health and safety of all persons involved, it is of the utmost importance that deleading is safely and correctly done in a timely manner. The following specific safety requirements are the responsibility of the Deleading Contractor.

K. General Safety:

1. General
   a. NO ONE is to be allowed in the work area without an approved respirator except for methods that have been documented not requiring a respirator.
   b. Each work area must be sealed from the remainder of the dwelling by taping plastic sheets (6 mil thick). Work areas must remain sealed off until both work and clean-up are completed.
   c. Cover all floors, carpets, furniture and appliances with 6 mil plastic within the work area. Use automotive masking tape (2 inches wide) to seal all edges and seams.
   d. Make certain all electrical connections are properly grounded.
   e. At least three days prior to the start of any deleading work, post appropriate warning signs at all entrances and exits of work areas and leave in place until all clearance testing indicates that these areas are safe for re-occupancy. The signs must include the following phrase: "CAUTION LEAD HAZARD-KEEP OUT". Post bilingual signs when necessary.
2. Worker Safety: The Deleading Contractor shall take the following minimum precautions to protect the health of all individuals involved in the deleading process.
   a. Pre-Abatement Medical Exam: Each employee shall undergo a medical examination to determine both respiratory fitness capability and also pre-existing/current blood lead level. Said results shall be provided to the employee and also to the Owner within 3 days of receipt of same, and in all cases, prior to employee's commencement to active abatement. Records of same are required to be kept by the Contractor for 40 years.
   b. Medical Surveillance is the monitoring of worker blood levels. It is required that the Contractor have blood level monitoring of all active abatement and clean-up workmen and on-site supervisors performed and said results provided to the Owner.
      1) Before assignment to active abatement activity for each worker.
      2) 30 days after active abatement has begun.
      3) At least every two months during the first six months and every six months throughout the deleading job.
      4) At least every two months for each employee whose blood lead analysis indicated a blood lead level at or above 25 micrograms per deciliter. (20 micrograms per deciliter for women of child bearing age).
      5) At termination of employment.
      6) Contractor shall reassign any employee whose blood lead has reached 25 µg/dl (20 µg/dl for women of child bearing age) to a job function deemed safe from lead exposure. Said employee shall remain away from active abatement until such time as 2 consecutive months' blood tests indicate µg/dl below 20 µg/dl.
   c. Respiratory Protection Programs must be established by the Contractor in accordance with OSHA regulations and qualitative respirator fit testing must be conducted daily by the on-site supervisor. Medical examinations must be performed by a physician prior to fit testing and at anytime when a worker demonstrates any difficulty breathing during the use of or the fit testing of respirators. The following are minimal acceptable respiratory protection program requirements as set up and administered by the Contractor:
      1) Written standard operating procedures which oversees the selection and use of respirators.
      2) Selection of respirators on the basis of hazards to which the worker is exposed.
      3) Worker training on the limitations and use of respirators (includes fit testing).
      4) Individual workers assigned respirators for their exclusive use only.

5) Daily cleaning and disinfecting of respirators.
6) Proper storage of all respirators.
7) Proper inspection of all respirators for wear and tear.
8) Continual surveillance of work area conditions and level of worker exposure or stress.
9) Use of approved respirators only, modified as needed by the weekly exposure monitoring results.
10) Supply weekly report covering items 1-9 to the Owner or its Lead Consultant.

d. Exposure Monitoring is the measured concentration of lead in the workers breathing zones. The Contractor shall perform personnel monitoring during active abatement using the NIOSH 7072 method and-shall be responsible for:
1) Monitoring the level of worker protection needed during the abatement process;
2) Evaluating, modifying and improving any engineering and work practice control(s) as needed;
3) Evaluating each employee's personal quality of work and any need for additional worker training or safety instruction;
4) Providing the Owner results of all personnel monitoring tests within 10 days of testing; and
5) Providing half-face APR respirators with HEPA filters unless said monitoring test results dictate differently. OSHA guidelines shall be used to determine respirator PEL protection factors.

e. Protective Clothing Equipment must be provided to all workers to help assure that lead dust is contained to the work areas. The following must be supplied/enforced by the Deleading Contractor:
1) Full body protective clothing and shoe covers of appropriate sizes on a daily basis or as needed.
2) Clean changing areas separated from the dirty/contaminated clothes storage area.
3) Water and wash facilities for washing of hands and face and shower facilities if deemed necessary by the Owner's Lead Advisor.
4) Instructing worker on proper maintenance of clothing and equipment.
5) Proper disposal of disposable clothing and proper permanent work clothes.
6) Enforcing the removal of protective clothing at the end of each work day and before eating, drinking and smoking.
7) Enforcement of the removal of protective shoe covers before leaving work area.

3. Contractor/Worker Daily Safe-Work Procedures

a. Daily Start-Up:
1) Workers to put on protective gear prior to entering work areas.
2) All garment seams to be sealed with duct tape.
3) All non-working garments must be stored in designated changing area.
4) Respirators, as required, must be properly fitted before entering work area. Perform qualitative fit test.

b. Temporary depart:
1) All protective clothing to be HEPA vacuumed while still being worn.
2) All shoe covers to be removed and left in the work area (immediate departure upon removing).
3) Remove all protective gear in designated "contaminated" changing area before eating, drinking, and smoking or before leaving work site.
4) Wash hands and face.
5) Clean respirators.

c. Daily Shut-Down:
1) Dispose of protective clothing with abatement waste by sealing in a 6 mil poly bag.
2) Laundered clothes must be placed in closed container.
3) Wash hands and face.
4) Shower if facilities allow and circumstances dictate.
5) Clean all protective gear (respirators included).

4. Tenant's Safety: Temporary relocation of the tenants is necessary if the lead paint surface is broken. Temporary relocation of the tenants and their belongings is the responsibility of the Owner. However, the Contractor has the joint responsibility to administer and enforce the following safety practices on behalf of the occupants:
   a. Adults
      1) NO OCCUPANT is allowed to enter the work area during paint removal and initial clean-up. A three day clean-up and settlement period may be imposed depending upon the abatement procedures used, at the discretion of the Owner or their Lead Consultant.
      2) the Owner shall notify all occupants in writing when they are allowed to return to their post-abated residence. Contractor shall abide by these notices.
      3) Every resident who has received prior notice of abatement is responsible for placing all personal items (clothing, dishes, linens, etc.) in closed, easy to handle containers; and move such items to the center of each room as requested.
      4) As long as visible dust remains, occupants may not occupy dwelling, and all surfaces within the dwelling must be re-washed with trisodium phosphate and HEPA vacuumed by deleading contractor.
      5) Persons reoccupying dwellings following abatement are required to report any visible dust or debris to the Owner immediately for additional Contractor clean-up.
   b. Pregnant Women and Children
      1) Absolutely no pregnant women nor children under the age of twelve years of age may be allowed in the building while any part of the abatement process is going on.

END OF SECTION 13285a

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SECTION 13285b - XRF TESTING FOR LEAD-BASED PAINT

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for XRF testing for lead-based paint. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

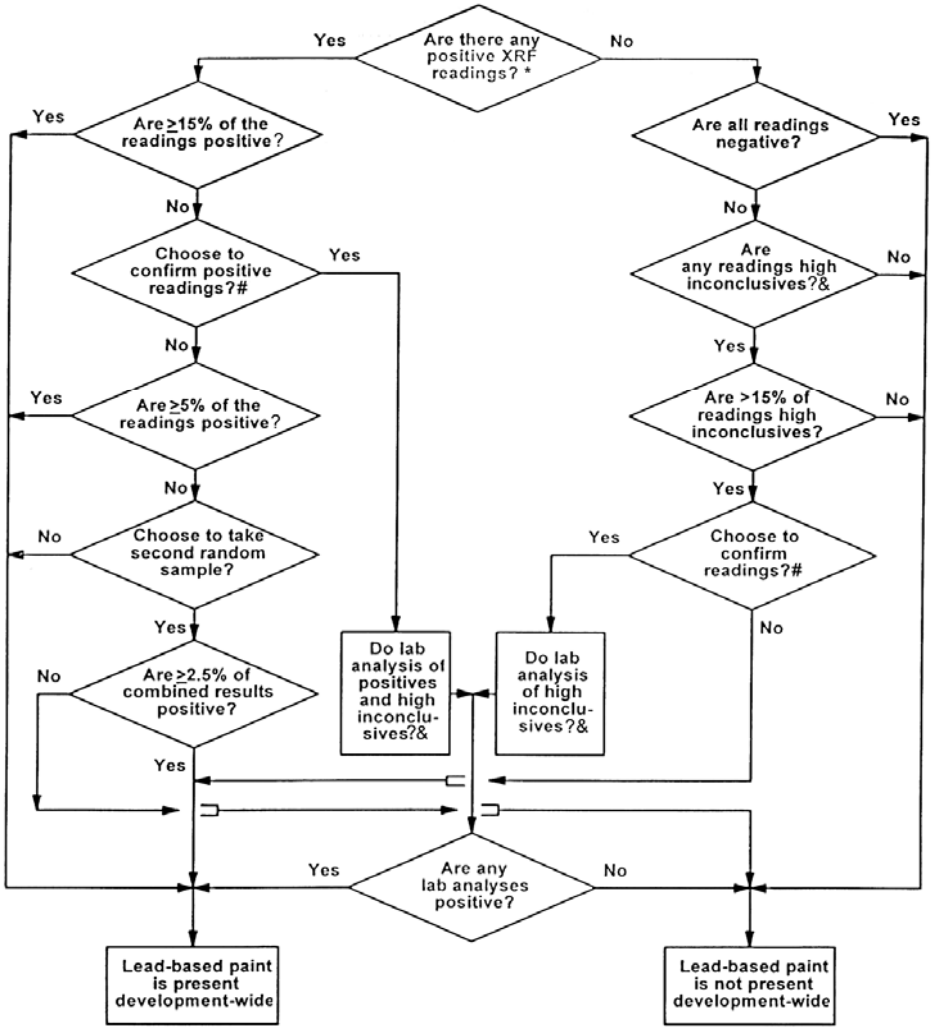
GENERAL

Inspection Rules: The Contractor will be required to comply with the following inspection rules. These inspection rules (the "Inspection Rules"), which appear in this section for the various XRF machines, are also known as "IP-4". The Inspection rules are subject to modification upon written notice by the Owner.

1. Random Sampling Program - Multi-family housing testing rules.
   a. In order to use the Multi-family housing testing rules, there must be:
      1) 21or more units (pre-1960 construction) and all must have a similar construction and original painting history, or
      2) 10 or more units (construction from 1960-1977) and all must have a similar construction and original painting history.
   b. Determine the number of randomly selected units to be tested from Table 7.3, Chapter 7, in the HUD guidelines. Chapter 7 of the HUD Guidelines also describes how to select the units randomly. If a unit or units which were selected as part of the original random sample cannot be entered for a particular reason, a replacement unit(s) must be randomly selected in accordance with the HUD Guidelines.
   c. All testing must be done in strict accordance with the HUD guidelines except as such Guidelines are modified by the Owner in writing in this Agreement. As per the HUD Guidelines, an assessment on each tested component must note four attributes, also called a testing combination.
      1) The room equivalent (where the testing took place i.e. bedroom, bathroom, etc.)
      2) The component type (door, wall #1 - upper left, etc.)
      3) The substrate (brick, wood, concrete, drywall, plaster or metal).
      4) The color of the paint.
   d. These attributes must be included as part of the report.
   e. For each testing combination, the condition of the painted surfaces should be noted as either intact, fair or poor.
   f. One reading with the X-ray fluorescence (XRF) instrument on each testing combination is all that is required.
   g. At least 40 components of a given type must be tested to obtain the desired level of confidence in the results throughout the multi-family development. If less than 40 components of a given type exist in the buildings to be tested i.e. they are unique components, then the measurement should be taken using single family testing rules (described below). If less than 40 components of a given type exist in the units to be tested, additional components of this type can be identified in other units in the complex and tested to bring the total up to 40 so that multi-family testing rules can be used. The decision of which option the Contractor should use will be made by the the Owner.
   h. To increase the number of tested components of a given type, testing combinations with different colors on the same component and substrate may be combined into a single component type. For example, if "wood doors" is the component type, all wood doors tested for lead-based paint could belong to the same component type, regardless of color.
   i. A component type may be differentiated by color as long as there are 40 tested and there is a good reason for differentiation.

j. The XRF measurements, corrected for substrate contribution, if required by the Performance Characteristic Sheet ("PCS") for the particular type of instrument being used, should be sorted by the inspector by component type into the following categories:
   1) Positive- A positive XRF reading in accordance with the XRF's Performance Characteristic Sheet.
   2) Negative- A negative XRF reading in accordance with the XRF's Performance Characteristic Sheet.
   3) High Inconclusive- An inconclusive XRF reading equal to or greater than the midpoint of the XRF's inconclusive range, in accordance with the XRF's Performance Characteristic Sheet.

k. The following Decision analyses will be used to determine which components are positive or negative:



* *"Positive," "negative," and "inconclusive" XRF readings are determined in accordance with the XRF instrument's Performance Characteristics Sheet as described in the HUD Guidelines for the Evaluation and Control of Lead Hazards in Housing, chapter 7.*

& *A high inconclusive reading is an XRF reading at or above the midpoint of the inconclusive range. For example, if the inconclusive range is 0.41 to 1.39, its midpoint (average) is 0.90; a reading in the range from 0.90 to 1.39 would be a high inconclusive reading.*

\# *Any paint or coating may be assumed to be lead-based paint, even without XRF or laboratory analysis. Similarly, any XRF reading may be confirmed by laboratory analysis.*

l. If there are readings on a component type(s) equal to or greater than 1.0 mg/cm² and paint chip samples are submitted to the laboratory, there are two possible results:

1) If all lab samples on a component type are below 0.5% lead by weight, the component type can be classified as negative throughout the development.
2) If one or more lab results are positive, (equal to or greater than 0.5% lead by weight for a component) the the Owner will take one of three options:
   a) Treat the component type as positive throughout the development, or
   b) Test the component type throughout the development, or
   c) If 5% or less of the component type are positive, take a second random sample, just testing that component type.

3) If option 2)c) above is selected by the Owner and the combined results of the first and second random sample are less than 2½% positive, the following additional options are available depending on the results.
   a) If no positives are found in the second sample, no further testing is necessary. Those positives in the first random sample will be monitored/abated (not by this Agreement), but the rest of the component type can be classified as negative.
   b) If positives are found on a component type in the second sample, the the Owner has the option to classify the component type as positive throughout the development or comprehensively test it.
   c) If the combined results of the two random samples are equal to or greater than 2½%, the the Owner also has the option to comprehensively test the remaining components of that type or classify them as positive.

m. Paint Chip Sample Size: The Paint chip samples should be taken from a 4 square inch (25 square centimeter) area that is representative of the paint on the testing combination, as close as possible to any XRF reading locations and, if possible, unobtrusive. This area may be a 2" x 2" (5 x 5 centimeters) square, or a 1" x 4" (2.5 x 10 centimeters) rectangle, or have any other dimensions that equal at least 4 square inches (25 square centimeters). Regardless of shape, the dimensions of the surface area must be accurately measured (to the nearest millimeter or 1/16th of an inch) so that the laboratory results can be reported in mg/cm$^{2.}$ Results should be reported as percent by weight if the surface area cannot be measured accurately or if all paint within the sampled area cannot be removed. In these cases, lead should be reported in ppm or percent weight, not in mg/cm^2. Smaller surface area can be used if acceptable to the laboratory. (See ASTME 1729). In all cases those who take the samples should consult with the NLAAP recognized laboratory selected regarding the requirements for the submission samples for lead-based paint analysis.

n. If the the Owner decides to test in search of these hard-to-find components coated with lead based paint, the inspector must use the single family testing rules described in the next section.

2. Single Family Testing Rules
   a. If the housing development has less
      1) than 10 units built between 1960-1970 or
      2) 20 units built before 1960 or
      3) the random testing rules in a multi-family development are not being used

      then single family testing rules must be followed.
   b. All inconclusive results must be confirmed with laboratory analysis, or as an alternative must be classified as positive. the Owner may also wish to confirm positive XRF results with laboratory analysis. Therefore the Contractor must make a field determination of which XRF readings falls in the inconclusive or positive ranges and take paint chip samples during the XRF testing for possible laboratory analysis. If the majority of XRF readings are positive in the first few units, the inspector must consult with the Owner on whether to continue taking paint chip samples.

      Only the Owner may determine whether to submit collected paint chip samples for laboratory analysis or to classify the element as positive.

3. Similar common areas and similar exterior sites must always be tested, but in some cases they can be sampled in much the same way that dwelling units are. Common areas and building exteriors typically have a similar painting history from one building to the next. In multifamily housing, each common area (such as building lobby, laundry room, or hallway) can be treated as a dwelling unit. If there are multiple similar common areas, they may be grouped for sampling purposes I exactly the same way as regular dwelling units. However, dwelling units, common areas and exterior sites cannot be all mixed together in a single group. All testing combinations within each common area or building exteriors selected for testing must be inspected. This includes playground equipment, benches and miscellaneous testing combinations located throughout the development. The specific common areas and building exteriors to test should be randomly selected, in much the same way as specific units are selected using random numbers.

The number of common areas to be tested should be taken from table 7.3 (HUD Guidelines). In this instance, common areas and building exteriors can be treated in the same way as housing units (although they are not to be confused with true housing units).

4. Unit and common area drawings
   a. Mark-ups of as built drawings depicting room equivalents that are tested must be provided as part of the report.
   b. The Contractor should test in a clockwise path starting from the door through the space and room equivalents so that the approximate location of each component tested can be easily established by referencing the room equivalent and sides.
   c. Each space must have a reference point (side A, B, C, D or wall 1, 2, 3 or 4). The wall with the door should always be referenced as wall 1 or side A. If there is more than one door, wall 1 or side A should be used to refer to the wall with the door through which the room is first entered when moving in a clockwise fashion through the unit.
5. XRF Instruments and testing protocols
   a. The Contractor has the option to use any of the following instruments for the XRF testing: Scitec MAP 4 Spectrum analyzer, Princeton Gamma-Tech XK-3, Warrington MicroLead 1, Revision4, TN Technologies (TN Spectrace) PB analyzer, Radiation Monitoring Devices LPA-1, Advanced Detector-Leadstar, or the Niton XL-309 Spectrum analyzer.
   b. Chapter 7 of the HUD guidelines 1997 Revision, assumes that the standard for classifying paint as toxic for lead is 1.0 mg/cm². The PCS of these instruments have established inconclusive ranges/thresholds by substrate type based on the 1.0 mg/cm² standard. These ranges/thresholds are interim ranges/thresholds which are subject to review by HUD; however they must be used by the Contractor unless and until the Contractor is notified otherwise in writing by the Owner. Therefore the following table should be used to determine which readings falls in the inconclusive ranges/thresholds. the Owner reserves the right to modify these inconclusive ranges/thresholds by notice in writing to the Contractor.
6. Evaluation of the Inspection by the the Owner
   a. The Contractor will be required to carry out retesting at no additional cost to the the Owner, after completion of the Inspection at each the Owner development as described in the HUD Guidelines on page 7-17, section H, and page 7-28, section H, for single family housing and multi-family housing respectively. As per the HUD Guidelines, the the Owner shall randomly select the testing combinations to be retested and the Contractor shall perform the retesting using the same XRF instrument(s) which was/were used to take the original readings. A the Owner inspector shall be present to observe all retesting. The retesting shall be limited to ten (10) testing combinations, and if necessary to repeat the retest, the testing combinations randomly selected for repeating the retest shall also be limited to ten.
   b. If the retest tolerance limit computed from the information provided in the XRF Performance Characteristics Sheet is exceeded, the retest will be repeated as described in the HUD Guidelines page 7-18, section H both for single family and multi-family housing. If the retest tolerance limit is exceeded again, the the Owner may require the Contractor to retest the entire development at no additional cost to the the Owner, or the the Owner may withhold all payments and terminate its agreement with the Contractor.
7. Option to do Laboratory Testing only
   a. The the Owner may, for a specific testing assignment, request in writing that the Contractor, when utilizing the multi-family housing testing rules for random sampling, or the single family housing testing rules, do all testing through laboratory analysis of paint chips rather than through XRF Spectrum Analyzer testing with laboratory confirmation as needed. Please note that under the single family housing testing rules, only one paint chip must be taken and analyzed for each component type.

Scope Of Work: The work shall consist of furnishing all labor, material, insurance and all other incidental items required to do the following:

8. XRF Testing

a. Random or comprehensive testing of various components in apartments in various Projects using any of the X-ray Fluorescence ("XRF") machines listed in section IIID, to determine if the lead-based paint concentration is within permissible limits.
   Note: Testing may be for entire apartments or selected rooms or components within the apartment.
b. The permissible limit shall be defined as a final reading showing a lead concentration of less than 1.0 mg/cm².
c. Refer to the Manufacturer's manual, as well as the "XRF Performance Characteristic Sheet" when determining calibration check tolerance, and other instrument specific information. Use the adjusted "XRF Performance Characteristic Sheets" in this contract when determining the inconclusive range.
d. In addition to the manufacturer's recommended warm up and quality control procedures, a set of three nominal XRF calibration check readings must be taken before the inspection begins and after the inspection has been completed in a particular unit, or every 4 hours, whichever occurs first. All reference material values and calibration check readings must be included in the report provided to the Owner.
e. Do not use the XRF to test highly curved or ornate surfaces, or surfaces inaccessible to the XRF, due to poor reliability of results. For such surfaces, laboratory analysis of paint chips must be done.
f. Only one XRF reading is required per testing combination. A unique testing combination is characterized by the room equivalent, the component, the substrate and the visible color of the paint. However, testing combinations with different colors on the same component and substrate may be combined into a single component type.
g. All inconclusive results must be treated according to the inspection rules using multi-family inspection or single family inspection rules as appropriate.
h. XRF field data sheets shall be filled out as they appear on completed Form 7.1 and 7.5 Guidelines.
i. Room equivalents or sections thereof that are not accessible for testing (i.e. locked bedrooms) shall be noted in the final report to the Owner.

9. Laboratory testing of paint chips.
   a. Collection of paint chips from various painted components in various Projects for laboratory analysis due to XRF substrate corrected inconclusive and/or positive readings as directed by the the Owner.
   b. Laboratory preparation and testing by Flame Atomic Absorption Spectrometry (FAAS) or Graphite Furnace Atomic Absorption Spectrometry (GFAAS) to determine if the lead paint concentration is within permissible limits.
   c. The permissible limit shall be defined as a lead concentration less than 0.5% by weight.
   d. Collect paint chips in accordance with ASTM ES28-94.
   e. Prepare paint chips in the laboratory for testing in accordance with ASTM ES37-94.
   f. Repair and repaint areas from which paint chips have been collected, to match adjacent areas, unless notified by the the Owner in writing to utilize a temporary covering for the tested surfaces. The Contractor shall provide water based latex paint for this purpose. Colors shall be limited to white and off-white; and other colors if provided by the tenant.
   g. Only one paint chip is required per testing combination. A unique testing combination is characterized by the room equivalent, the component, the substrate, and the visible color of the paint. However, testing combinations with different colors on the same component and substrate may be combined into a single component type.
   h. Field data sheets and signed chain of custodies must be attached to the final report to the Owner.
10. The Contractor shall send notices to the Project Superintendent, Residents, and the Department of Planning and Development 48 hours before the scheduled start of work. The Contractor shall make three (3) attempts to gain entry to each apartment, with proper 48 hour notification to the resident each time.
11. The Contractor shall begin work no later than 48 hours after receiving a work proceed order.

12. The Contractor shall perform work in accordance with the latest HUD Guidelines, except as such guidelines are modified by the Owner in writing in this contract or any contract pursuant to this contract, and in accordance with all applicable Federal, State and Local regulations.
13. Workmanship required in the execution of the work herein specified shall be of good quality and subject to the approval of the the Owner.

XRF Testing Report Format

14. All XRF report must be made after a formal submittal and approval by the Owner.
15. A faxed summary report must be provided to the the Owner within 48 hours after completion of testing for a work Authorization. For XRF testing requiring confirmation by laboratory analysis of paint chip samples, the faxed summary report must be provided within 48 hours after the the Owner gives approval for testing of the collected paint chip samples.
16. A detailed report must be provided to the the Owner within 5 business days after completion of the testing.

General Provisions

17. Some of the work of this contract will be in occupied apartments. The Contractor shall perform all of the work of this contract with the least inconvenience to the tenants.
18. The Contractor shall take all necessary precautions to protect the property of the the Owner, its residents and the public. The contractor must repair any damaged property, whether of the the Owner, its residents, or the public, and restore such property to its original condition. If the damage is beyond repair, the Contractor shall replace it with new, that in the judgement of the the Owner, match the existing materials and are of equal quality and workmanship. All such repairs shall be at the Contractor's expense.
19. The Contractor shall begin work no later than 48 hours after receiving a work proceed order.
20. The Contractor shall perform work in accordance with the latest HUD Guidelines, except as such guidelines are modified by the Owner in writing in this Contract, or any Contract pursuant to this Contract, and in accordance with all applicable Federal, State and Local regulations.
21. The Contractor shall include in the bid price all supplementary miscellaneous items not specified but implied or required in order to complete the work.

Applicable Regulations

22. All work of this contract shall be in strict accordance with the HUD Guidelines.
23. All work of this contract shall also be in accordance with applicable regulations of the Environmental Protection Agency (EPA), Occupational Safety & Health Agency (OSHA) and any applicable State or Local standards that may be more stringent than the Federal Standards.
24. OSHA Standards (without limitation), include:
    - 29 CFR 1926.20 - General safety and health provisions;
    - 29 CFR 1926.21 - Safety training and education;
    - 29 CFR 1925.25 - Housekeeping;
    - 29 CFR 1926.28 - Personal protective equipment;
    - 29 CFR 1926.51(f) - Washing facilities;
    - 29 CFR 1926.55 - Gases, vapors, fumes, dusts, and mists;
    - 29 CFR 1926.57 - Ventilations;
    - 29 CFR 1926.59 - Hazardous Communication Standards;
    - 29 CFR 1926.103 - Respiratory protection; and
    - 29 CFR 1926.62 - Lead in Construction
25. The Contractor must comply with all applicable requirements of the Resource Conservation & Recovery Act (RCRA) of 1976 as amended in 1980 and 1984 by the Hazardous & Solid Waste Amendments (HSWA).

Qualification Requirements

26. Copies of the submissions listed below must be tendered with the bid:
    a. Ability to perform XRF testing and paint chip sampling by submitting evidence of the successful completion of lead inspector training by all staff to be assigned to the job including inspector technicians. Training must be provided through a State approved EPA-

Model program. All staff assigned to the Contract must also demonstrate training in the use of the XRF testing machines to be dedicated to this contract. The serial number of such XRF machine shall be provided to the the Owner.

1) Contractor or Subcontractor performing the work must have at least 3 years of satisfactory experience (documented) in performing XRF testing for a City, State or Federal Agency.

b. Laboratory certification by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.

c. If a subcontractor will be used for any of the laboratory work of this contract, evidence of certification stated above must also be provided for the subcontractor.

Waste Disposal

27. All waste generated must be legally disposed in accordance with Federal, State and Local regulations.

END OF SECTION 13285b

SECTION 13285c - LEAD DUST WIPE, AIR AND TCLP SAMPLING AND ANALYSIS

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for lead dust wipe, air and TCLP sampling and analysis. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

Definitions: Unless otherwise specified the following definitions shall apply:

1. **"Approved"**: shall mean approved by all public agencies having jurisdiction, and the Owner.
2. **"The Owner"**: shall mean the Owner and its designated authorized representatives.
3. **"Contractor"**: shall mean the firm that is awarded this contract and is responsible to ensure compliance with Federal, State and City regulations as well as these Contract documents.
4. **"Development or Project"**: a group of buildings in one or more designated geographical locations, owned or operated by the Owner and referred to by a common name by the Owner.
5. **"Dust Cleaning Firm"**: shall mean the contractor under a separate contract or the Owner responsible for cleaning of lead dust, as directed by the Owner, until the clearance levels are achieved, as defined in the "Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing, June 1995" or latest edition published by the United States Department of Housing and Urban Development (HUD).
6. **"Equal or Approved Equal"**: shall mean equal in the opinion of the Owner.
7. **"HUD"**: the United States Department of Housing and Urban Development.
8. **"HUD Guidelines"**: shall mean Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing issued by HUD'S Office of Lead-Based Paint Abatement and Poisoning Prevention in June 1995 except as such guidelines are later modified by HUD and/or modified by the Owner in writing pursuant to this contract.
9. **"Inspector"**: an individual who has completed training from an accredited program and been licensed or certified by the appropriate State or local agency to (1) perform inspections to determine and report the presence of lead-based paint on a surface-by-surface basis through on-site testing, (2) report the findings of such an inspection, (3) collect environmental samples for laboratory analysis, (4) perform clearance testing, and (5) document successful compliance with lead-based paint hazard control requirements or standards.
10. **"Lead-Based Paint"**: any paint, varnish, shellac, or other coating that contains lead equal to or greater than 1.0 mg/cm² as measured by XRF or laboratory analysis, or 0.5 percent by weight (5,000 µg/g, 5,000 PPM, or 5,000 mg/kg) as measured by laboratory analysis.
11. **"Lead-Based Paint Hazard"**: a condition in which exposure to lead from lead-contaminated dust, lead-contaminated soil or deteriorated lead-based paint would have an adverse effect on human health (as established by the EPA Administrator under Title IV of the Toxic Substance Control Act). Lead-based paint hazards include for example, deteriorated lead-based paint, leaded dust levels above applicable standards and bare leaded soil above applicable standards.
12. **"Lead-Based Paint Hazard Control"**: activities to control or eliminate lead-based paint hazards, including interim controls and complete abatement.
13. **"Lead-Contaminated Dust"**: surface dust in residences that contain an area or mass concentration of lead in excess of the standard established by the EPA Administrator, pursuant to Title IV of the Toxic Substance Control Act. Until the EPA standards are set, the HUD recommended clearance and risk assessment standards for leaded dust are 40 µg/ft² on floors, 250 µg/ft² on interior window sills, and 800 µg/ft² on window troughs.
14. **"Monitoring"**: shall refer to inspection to ensure compliance with all Federal, State and City Standards or guidelines, and contractual specifications.
15. **"Provide"**: shall mean furnish and install.

16. **"Risk Assessor"**: a certified individual who has completed training with an accredited training program and who has been certified to (1) perform risk assessments, (2) identify acceptable abatement and interim control strategies for reducing identified lead-based paint hazards, (3) perform clearance testing and reevaluations, and (4) document the successful completion of lead-based paint hazard control activities.

Applicable Regulations/References

17. The work conducted shall comply with all applicable Federal, State and City regulations. Applicable guidelines and standards listed in the scope of work include, but are not limited to:

24 CFR Parts 35,36,37	HUD Lead-Based Paint Regulations
Guidelines for the Evaluation and Control of Lead-Based Paint in Housing (HUD Guidelines June 1995) & 1997 Revisions	
29 CFR 1910	General Industry Standard
29 CFR 1910.1025	Lead Standard for General Industry
29 CFR 1910.134	Respiratory Protection
29 CFR 1910.1200	Hazard Communication
29 CFR 1910.245	Specification for Accident Prevention
29 CFR 1926	Construction Industry Standards
29 CFR 1926.20	General Safety & Health Provisions
29 CFR 1926.21	Safety Training & Education
29 CFR 1926.25	Housekeeping
29 CFR 1926.28	Personal Protective Equipment
29 CFR 1926.51	Washing Facilities
29 CFR 1926.55	Gases, Vapors, Fumes, Dusts & Mists
29 CFR 1926.59	Hazard Communication Standard
29 CFR 1926.62	Construction Industry Lead Standard
29 CFR 1926.103	Respiratory Protection
40 CFR 61 Subpart A	General Provisions
40 CFR 241	Guidelines for the Land Disposal of Solid Waste
40 CFR 257	Criteria for the Land Disposal of Solid Waste
40 CFR 261/262	Waste Disposal Facilities & Practices
American National Standards Institute (ANSI) Z87.1	Eye Protection
ANSI Z88.2-80	Practices for Respiratory Protection
American Society For Testing Materials (ASTM)	All Applicable Standards

18. The contractor shall ensure that any programs, certifications, licenses or other documentation in accordance with the above and/or any other applicable Federal, State, and Local Regulations/Guidelines are provided.

Scope Of Work

19. The work shall consist of furnishing labor, materials, insurance and all other incidental items required to perform the following:
    a. Dust wipe sampling and analysis
        1) Collect dust wipe samples from various horizontal surfaces, such as floors, window sills, window troughs, etc., as directed by the Owner.
        2) Dust wipe samples shall be collected in accordance with ASTM ES30-94.
        3) Analyze dust wipe sample in the laboratory using Flame Atomic Absorption Spectrometry ("FAAS") or Graphite Furnace Atomic Absorption Spectrometry("GFAAS").
        4) Provide result of analysis in micrograms per square foot.

5) A faxed summary of results must be provided to the Owner within 24 hours after the Owner authorizes the Contractor to perform the laboratory analysis of the collected dust wipe sample. Contractor shall also have the ability to provide results in 4 hours for clearance, following lead-based paint abatement work, if requested by the Owner. The sampling result must be provided in a form approved by the Owner and must include for each dust wipe sample, the Project, the building address, the sample number, the room or room equivalent, the surface type, dimensions of sample areas, total micrograms, micrograms per square feet, and an indication of pass or fail.

6) Turn-around time for results shall be counted from the time the Contractor performs collection of dust wipe samples to the time the results are actually presented to the Owner. This includes travel time from the site to the laboratory of the Contractor and back to the site.

7) A detailed final report covering the results of all dust wipe samples taken and analyzed must be submitted within 5 days from the time the Owner authorizes the performance of the laboratory analysis. The sampling report must include for each dust wipe sample, the Project, the building address, the sample number, the room or room equivalent, the surface type, dimensions of sample areas, total micrograms, micrograms per square feet, and indicate pass or fail in a form approved by the Owner. Also include in the report the method of analysis, i.e. "FAAS" or "GFAAS", and the detection limits. The laboratory test results in the final report must be signed by the Laboratory Director.

8) The sampling data report must contain all required data fields as specified by the Owner. The sampling data report shall be provided to the Owner on 3.5 inch high density diskettes in ASCII file form. The required data fields will be provided by the Owner to the Contractor.

9) The laboratory used for the analysis of the dust wipe samples must be certified by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.

b. Dust Spiked Samples

1) Provide dust spiked samples to the Owner. Dust spiked samples shall be prepared in accordance with the HUD Guidelines.

NOTE: These samples are separate from the ones required by the Contractor for his own QA/QC

2) Prepare dust spiked samples in a manner such that they are indistinguishable from the field samples.

3) Prepare dust spiked samples using the same lot as that to be used in the field.

4) Dust spiked samples shall be inserted into the sample stream, randomly, by the Owner Inspector.

5) Blind analysis of dust spiked samples must fall within 80%-120% of the true value. If the laboratory fails to obtain readings within these limits, two more spiked samples shall be sent immediately to the lab for analysis.

6) If the two additional spiked samples fail, the sample batch shall be considered invalid, and the Owner may, at its sole discretion, terminate this contract as well as withhold payment for services already rendered.

c. Air Sampling and Analysis

1) Collect area air samples at various locations and various projects for personal exposure assessment as directed by the Owner.

2) Air samples shall be collected in accordance with ASTM E1553-93.

3) Prepare air samples for analysis in accordance with ASTM E33-94

4) Analyze air samples using FAAS or GFAAS.

5) All equipment required for personal air sampling, including pumps shall be provided by the Contractor at no extra cost to the Owner.
6) Provide results of air samples in micrograms per cubic meter.
7) A faxed summary of result must be provided to the Owner within 24 hours after the Owner authorizes the Contractor to perform the laboratory analysis of the collected air sample. The sampling result must include for each air sample taken the Project, the building address, the sample number, the room or room equivalent, and the reading.
8) Turn-around time shall start after collection of the air samples, and includes travel time to and from the laboratory.
9) A detailed final report covering the results of all air samples taken and analyzed must be submitted within 5 days from the time the Owner authorizes the performance of the laboratory analysis. The sampling report must include for each air sample, the Project, the building address, the sample number, the room or room equivalent, and the reading. The laboratory report contained in the final report must be signed by the Laboratory Director.
10) The sampling data report must contain all required data fields as specified by the Owner. The sampling data report shall be provided to the Owner on 3.5 inch high density diskettes in ASCII file form. The required data fields will be provided by the Owner to the Contractor.
11) The laboratory used for the analysis of the dust wipe samples must be certified by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"),or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.
12) Air sampling technician shall be present during the entire shift of the air sampling.

d. TCLP Sampling and Analysis
1) Take core samples of construction waste as directed by the Owner and analyze by TCLP testing to determine if waste is hazardous.
2) Waste shall be classified as hazardous if the concentration of lead is greater than 5 parts per million by TCLP testing.
3) The laboratory used for the analysis of the TCLP samples must be certified by the State Department of Health (or other responsible agency) and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP, and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided. Indicate if the laboratory is an independent entity from the Contractor.
4) A faxed summary of result must be provided to the Owner within 48 hours after the Owner authorizes the Contractor to perform the TCLP analysis of the waste. Provide results in parts per million (ppm).
5) Final results provided to the Owner by the Contractor must include written sample preparation procedure and laboratory specific written procedures for performing TCLP, including quality control procedures used for performing the TCLP, and a table listing the sample numbers, description of the construction waste, and the result of the TCLP. The laboratory report contained in the final report must be signed by the Laboratory Director.
6) Final report must also specify detection limits.
7) Final report must be provided within 5 days from the time the authorization to perform the TCLP is given by the Owner.

General Provisions

20. Some of the work of this contract may be in occupied apartments. The Contractor shall perform all of the work of this contract with the least inconvenience to the tenants.
21. The Contractor shall take all necessary precautions to protect the property of the Owner, its residents, and the public. The Contractor must repair any damaged property, whether of the Owner, its residents, or the public, and restore such property to its original condition. If the damage is beyond repair, the Contractor shall replace it with new, that in the judgment of the Owner, match the existing materials and/or of equal quality and workmanship. All such repairs shall be at the Contractor's expense.
22. The Contractor shall develop a work plan to be performed as requested by the Department of Planning and Development. The detailed plan shall include coordination of the monitoring and sampling work with the Contractor in a manner that will be least disruptive to the normal use of the non-work areas in the building. The plan should also include emergency procedures in case of fire.
23. The Contractor shall perform work in accordance with the latest HUD Guidelines, except as such Guidelines are modified by the Owner in writing in this Contract, or any Contract pursuant to this Contract, and in accordance with all applicable Federal, State and Local regulations.
24. The Contractor shall include in the bid price all supplementary miscellaneous items not specified but implied or required in order to complete the work.

Submissions

25. Six (6) copies of the submissions listed below must be submitted to the Owner by the Contractor or Subcontractor performing the Work:
    a. Ability to perform lead dust wipe sampling by submitting evidence of the successful completion of lead inspector and/or risk assessor training <u>by all staff to be assigned to the job</u> including inspector technicians. As stated previously, training must be provided through an approved program.
    b. Laboratory certification by the State Department of Health (or other responsible agency) through its ELAP program and by the USEPA through the EPA's National Lead Laboratory Accreditation Program ("NLLAP"), or as an alternative having accreditation application pending before NLLAP and having acceptable performance on five consecutive rounds of the EPA, Environmental Laboratory Proficiency Analytical Testing (ELPAT) program, including the most recent round; evidence of such accreditation must be provided.
    c. If a subcontractor will be used for any of the laboratory work of this contract, evidence of certification stated in (2) above must also be provided for the subcontractor.

Waste Disposal

26. All waste generated must be legally disposed in accordance with the Federal, State and Local Regulations.

END OF SECTION 13285c

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Task	Specification	Specification Description
13289	01352	No Specification Required
13289	02115a	Excavation And Handling Of Contaminated Material
13289	13285	Removal And Disposal Of Lead-Containing Paint
13289	13285a	Lead Paint Related Abatement Procedures
13289	13285b	XRF Testing For Lead-Based Paint
13289	13285c	Lead Dust Wipe, Air And Tclp Sampling And Analysis

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SECTION 13720 - PERIMETER SECURITY

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for perimeter security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Perimeter protection with electrostatic-field, strain-sensitive cable, buried, ported coaxial cable, long-range PIR detectors, geophone fence detectors, video motion sensors, gate units and microwave systems, integrated into a single perimeter detection and alarm system.

C. Definitions
1. EMI: Electromagnetic interference.
2. LED: Light-emitting diode.
3. PIR: Passive infrared.
4. RFI: Radio-frequency interference.
5. UPS: Uninterruptible power supply.
6. Protected or Protection Zone: A space or area for which an intrusion must be detected and uniquely identified, the sensor or group of sensors assigned to perform the detection, and any interface equipment between sensors and communication link to central-station control unit.
7. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
8. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

D. Submittals
1. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
a. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers **OR** networks, **as directed,** and control interface devices and media to be used. Describe characteristics of network and other data communication lines.
b. Raceway Riser Diagrams: Detail raceway runs required for perimeter security and for systems integration. Include designation of devices connected by raceway, raceway type, and size, and type and size of wire and cable fill for each raceway run.
c. UPS: Sizing calculations.
d. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for central-station control-unit console, terminal cabinet, racks, and UPS.
e. Central-Station Control-Unit Console Layout: At 1" = 1'-0" (1:12) scale, showing required artwork and device identification.
f. Device Address List: Coordinate with final system programming.

g. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
h. Details of surge-protection devices and their installation.
i. Sensor detection patterns and adjustment ranges.

3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are not acceptable.
4. Samples: For each type of exposed finish required.
5. Qualification Data: For Installer, security systems integrator, and testing agency.
6. Field quality-control test reports.
7. Operation and Maintenance Data: For perimeter security system to include in emergency, operation, and maintenance manuals. Include the following:
   a. Data for each type of product, including features and operating sequences, both automatic and manual.
   b. Central-station control-unit hardware and software data.
8. Warranty: Special warranty specified in this Section.
9. Other Information Submittals:
   a. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
   b. Examination reports documenting inspections of substrates, areas, and conditions.
   c. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

E. Quality Assurance
1. Installer Qualifications:
   a. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
   b. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Security Systems Integrator Qualifications: An experienced perimeter security equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
3. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the National Burglar & Fire Alarm Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Owner's insurance underwriter.
   a. Testing Agency's Field Supervisor: Person currently certified as an advanced alarm technician by the National Burglar & Fire Alarm Association to supervise on-site testing specified in Article 1.3.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. FMG Compliance: FMG-approved and -labeled perimeter security devices and equipment.
6. Comply with NFPA 70.

F. Project Conditions
1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   a. Altitude: Sea level to 4000 feet (1220 m).
   b. Central-Station Control-Unit Hardware: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.

c. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.

d. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

G. Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of perimeter security devices and equipment that fail in materials or workmanship within two years from date of Substantial Completion.

1.2 PRODUCTS

A. Functional Description Of System

1. Supervision: System components shall be continuously monitored for normal, alarm, supervisory and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
   a. Alarm Signal: Display at central-station control unit and actuate audible and visual alarm devices.
   b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.
   c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.
2. System Control: Central-station control unit shall directly monitor gate detection devices, perimeter detection units, and connecting wiring.
   OR
   System Control: One or more remote, addressable controllers operate under control of a central-station control-unit microcomputer in a multiplexed distributed control system or as part of a network. Controllers shall receive programming by multiplexed signal transmission from a central-station control-unit microprocessor or microcomputer and hold data in nonvolatile memory. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance, **as directed**.
3. Operator Commands:
   a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
   b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
   c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
   d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
   e. Protected Zone Test: Initiate operational test of a specific protected zone.
   f. System Test: Initiate system-wide operational test.
   g. Print Reports.
4. Timed Control at Central-Station Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
5. Automatic Control of Related Systems: Alarm or supervisory signals from certain perimeter security devices control the following functions in related systems:
   a. Switch selected lights.
   b. Open a signal path between certain intercommunication stations.
   c. Shift sound system to "listening mode" and open a signal path to certain system speakers.

d. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.

6. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When central-station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
7. Response Time: Two seconds between actuation of any alarm and its indication at central-station control unit.
8. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, controllers, and sensors from central-station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at central-station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
9. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
10. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

B. System Component Requirements

1. Compatibility: Detection devices and their communication features, connecting wiring, and central-station control unit shall be selected and configured with accessories for full compatibility with the existing equipment.
2. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
   a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 16 Section "Transient Voltage Suppression".
   b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 16 Section "Transient Voltage Suppression" as recommended by manufacturer for type of line being protected.
3. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
4. Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.
5. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to central-station control unit.
6. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to central-station control unit as an alarm signal.
7. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to central-station control unit.

8. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at central-station control unit for calibration, sensitivity, and alarm condition.

C. Enclosures
1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
2. Interior Electronics: NEMA 250, Type 12.
3. Exterior Electronics: NEMA 250, Type 4X fiberglass **OR** stainless steel, **as directed**.
4. Corrosion Resistant: NEMA 250, Type 4X PVC **OR** stainless steel, **as directed**.
5. Terminal cabinets in handholes and manholes shall be NEMA 250, Type 6 **OR** 6P, **as directed**.
6. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.

D. Secure And Access Devices
1. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
2. Key-Operated Switch: Change protected zone between secure and access conditions.

E. Strain-Sensitive Cable
1. Description: Strain-sensitive, coaxial transducer cable shall monitor chain-link-type and welded-mesh-type fence and generate an alarm when a standard intruder attempts to climb over, cut through, or lift fence fabric.
2. Environment: Suitable for exterior installation and the following conditions:
   a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
3. Transducer Cable:
   a. Ultraviolet-resistant cable furnished by system manufacturer.
   b. Suitable for up to 1000 feet (300 m) of sensor cable per single-zone controller and up to 2000 feet (600 m) of sensor cable per dual-zone processor.
   c. Sensitivity shall be uniform throughout its entire length, requiring only one variable sensitivity adjustment throughout its entire length.
4. Controller:
   a. Field mounted, with tamper switch at controller board.
   b. Electronic circuitry shall discriminate between acceptable fence movement and intrusion-related disturbances.
   c. Sensitivity, count control, and climb-over processors shall be adjustable with a minimum of five individual count-control and climb-over adjustments.
   d. Controller output shall have adjustable pulse width to adjust the time the alarm relay will activate per detected intrusion attempt.
5. System Performance:
   a. Immune to RFI and EMI environments; interference shall have no effect on normal operational characteristics.
   b. Trouble and Tamper: Entire sensor system shall be fully supervised with individually monitored tamper and supervision alarms. Disconnecting, cutting, or shorting of strain-sensitive cable results in supervisory alarm.
   c. Intrusion Simulation: Each zone shall have a self-test feature that, when activated by a signal from central-station control unit, will produce an intrusion alarm and verify operation of sensor.

F. Microwave Intrusion Detectors
1. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
   a. Movement Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.1 to 50 fps (0.03 to 15.2 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.

b. Detection range: 15 to 600 feet (5 to 180 m).
c. Range Sensitivity: Adjustable for setting area of protection between 15 to 500 feet (5 to 152 m) in range and from 2 to 40 feet (0.6 to 12 m) in beam diameter.
d. Trouble and Tamper: Fully supervised with individually monitored tamper and supervision alarms. System failure shall result in tamper alarm. System jamming or wrong modulation shall result in supervisory alarm.
e. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
f. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

2. Environment: Suitable for exterior installation and the following conditions:
a. Ambient Temperatures: Ranging from minus 30 to plus 158 deg F (minus 34 to plus 70 deg C) and in rainfall up to 4 inches (100 mm).

G. Electrostatic Field
1. Description: Electronically balanced phase electrostatic-field detection system consisting of a field generator that generates an electrical field in one or more field wires and that has two or more sensing wires, a sense filter, amplifier, and a controller. Detection fields shall have a minimum of four different frequencies so adjacent zones cannot interfere with each other.
2. Environment: Suitable for exterior installation and the following conditions:
a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
3. System Performance:
a. Detect, via sense wires, a compound signal form consisting of amplitude change, rate of change, and pre-set time disturbance that forms a "signature" of human movement. Generate an alarm when all exist simultaneously. Provide detection fields of not less than four different frequencies so adjacent zones do not interfere with each other.
b. Controllers: Single or multiple zone, with standby battery, and sense filter. Front panel with calibration meter, status of alarm transmitter, sensitivity selector, test point selector, power indicator, and power control. Controller shall reject signals due to wind and small objects striking the wires.
c. Standby-Battery Operation: 4 hours at minimum operating temperature, 8 hours at 90 deg F (32 deg C) with integral battery charger.
d. Motion Detection: Sense standard-intruder movement at rates from 0.15 to 26 fps (0.045 to 8.0 m/s).
e. Zone Length: Not to exceed 500 feet (152 m) **OR** 325 feet (100 m), **as directed**.
f. Supervision: Generate trouble signal if field or sense wires are cut or shorted to ground or to each other. Generate supervisory alarm if received signal is substantially reduced.
4. Insulators, Wire-Tensioning Devices, and Brackets: Manufacturer's standard for mounting and tensioning of wires.
5. Field and Sensing Wires: Stainless steel.

H. Buried, Ported Coaxial Cable
1. Description: Electrostatic-field detection system consisting of buried, parallel, ported coaxial cables that generate a detection field between cables.
2. Environment: Suitable for exterior installation and the following conditions:
a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
3. System Performance: One of two parallel cables receives a continuous wave signal from a transmitter module. Second cable, connected to a sensor module, detects, preamplifies, and analyzes variations in signal. When system senses "signature" of a standard intruder in the detection zone, based on mass, motion, and time of day, it generates an alarm.
a. Transmitter: Locate at one end of zone, with standby battery.

b. Preamplifier-Sensor: Locate at opposite end from transmitter, with standby battery.
c. Front panel with sensitivity calibration meter, calibrated self-test potentiometer, power switch, and LED normal and malfunction indicators.
d. Electromagnetic Radiation: Less than 50 mV per meter at 30 m.
e. Standby Battery Operation: 4 hours at minimum operating temperature, 8 hours at 90 deg F (32 deg C) with integral battery charger.
f. Motion Detection: Sense standard-intruder movement at rates from 0.17 to 26 fps (0.05 to 8.0 m/s).
g. Zone Length: Not to exceed 500 feet (152 m) **OR** 325 feet (100 m), **as directed**.
h. Zone Width: Not to exceed 15 feet (4.6 m), with an average width of 12 feet (3.7 m).
i. Zone Height: Approximately 3.3 feet (1.0 m), depending on sensitivity setting.
j. Supervision: Generate trouble signal if cable is cut or shorted to ground. Generate supervisory alarm if cabinets are tampered with.

4. Enclosures: Hinged cover with tamper switch and security fasteners.
5. Buried, Ported Coaxial Cable: Approximately 1/2-inch (1.3-mm) diameter, minimum 10 AWG center conductor, foam polyethylene dielectric, braided copper outer conductor, and polyethylene jacket.

I. Long-Range PIR Detectors
1. Environment: Suitable for exterior installation and the following conditions:
a. Ambient Temperatures: Ranging from minus 30 to plus 150 deg F (minus 34 to plus 65 deg C).
2. System Performance: Detect an interruption of dual-infrared light beams that link transmitters and receivers. Generate an alarm when signal is interrupted due to presence of an object that interrupts both beams.
a. Sensitivity: Field adjustable to allow adjustment of range from 25 to 500 feet (7.6 to 152 m), generating an alarm within 20 to 50 ms when both beams are interrupted.
b. Detection system shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
c. Motion Detection: Detect standard-intruder movement at rates from 0.1 to 50 fps (0.03 to 15.2 m/s).
d. Supervision: Generate supervisory alarm if any portion of system is tampered with.
e. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

J. Geophone Fence Detection
1. Description: Detect attempts to cut or climb the protected fence, using geophone sensors that respond to specific shock or vibrations.
2. Environment: Suitable for exterior installation and the following conditions:
a. Ambient Temperatures: Ranging from minus 30 to plus 150 deg F (minus 34 to plus 65 deg C).
3. System Performance:
a. Controller: 10 zone capacity for processing geophone generated analog signals. Each zone shall consist of not more than 10 sensors.
1) Adjustments: For each zone provide stepped gain control for sensitivity, and switches for geophone signal filters to minimize nuisance alarms. System shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
2) Trouble Condition Signal: Generate when any zone fails.
3) Supervisory Condition Signal: Generate on interference with controller operation or when detecting a break-in into a enclosure housing electronics.
b. Sensors: Fence mounted 20 feet (6 m) o.c.
c. Cable for Interconnection of System Components: Shielded, PVC jacketed and armored, as supplied by system manufacturer.

d. Test each zone simulating an alarm condition. Test by command from central-station control **OR** test switch at controller inside the enclosure, **as directed**.

K. Video Motion Sensor
1. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in EIA 170. Provide an alarm output for each video input.
   a. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
   b. Modular design that allows for expansion or modification of number of inputs.
   c. Adjustable Controls:
      1) Number of detection zones.
      2) Size of detection zones.
      3) Sensitivity of detection of each protected zone.
   d. Mounting: Standard 19-inch (480-mm) rack as described in EIA 310.
2. Environment: Suitable for installation in interior air-conditioned spaces.

L. Gate Units
1. Description: Balanced-magnetic type, UL listed for outdoor locations. Units shall be designed for mounting on single- or double-leaf swinging or rolling gates and have armored jumper cables between switch and stationary junction box for wiring to central-station control unit and tamper switches in junction box.
2. Device Performance: Bias magnet and at least three encapsulated-reed switches that resist compromise from introduction of foreign magnetic fields, with integral overcurrent protective device to limit current to 80 percent of switch capacity.
3. Remote Test: Simulate movement of actuating magnet from central-station control unit.

M. Controllers
1. Field-mounted controller that includes the power supply and controller, and provides for communications and control to and from the central-station control unit.
2. Field-mounted intelligent peripheral controller that includes the power supply and controller and detector specific functions, and provides for communications with the central-station control unit. Controller shall include read-only resident software needed for startup, a time clock, and all automatic operations. Software shall be downloaded from the central-station control unit.
3. Battery Backup: UPS, providing 6 hours of run time during a power outage, with 2-rate automatic battery charger to fully recharge batteries within 12 hours after normal power is restored.
   a. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy.
   b. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
4. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

N. Central-Station Control Unit
1. Microprocessor System: Standard personal computer of modular design.
   a. CPU Word Size: 64 bits or larger.
   b. Operating Speed: 500 MHz or faster.
   c. Memory: 258 MB or more.
   d. Ports (Minimum):
      1) Two USB ports.
      2) COM 1 and COM 2.
      3) One enhanced parallel port.
      4) Two serial ports, with adjustable data transmission rates from 9.6 to 57.6 Kbps, selectable in software.

e. Video Card: Supports at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum rate of 70 Hz.

2. Monitor: Not less than 17 inches (430 mm) with minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm.
3. Keyboard: 101 keys, standard commercial type.
4. Peripherals: Special function keyboards **OR** Touch-screen devices, **as directed,** or mouse for frequently used operator commands such as the following:
   a. Help.
   b. Acknowledge alarm.
   c. Place protected zone in Access.
   d. Place protected zone in Secure.
   e. Protected zone Test.
   f. System Test.
   g. Print Reports.
   h. Change Operator.
   i. Security Lighting Controls.
   j. Display Graphics: Include operator commands as required to meet Project requirements.
5. Disk Storage:
   a. Hard disk with controller having a maximum average access time of 10 ms, and a disk with at least 60 Gigabytes of formatted storage.
   b. Floppy Disk: Drive and controller for standard 3-1/2-inch high-density diskettes.
   c. Removable Disk Storage: 100 **OR** 250, **as directed,** MB (minimum) drive and controller, with 10 diskettes.
   d. CD-ROM Drive: 40x (minimum) speed, 650 MB Read-Only data storage, 650 MB recording capacity using CD-R technology, with software and 10 CD-R blank disks and 1 test disk.
   e. Modem: 56K, v.90 data/fax with error detection, auto answer/autodial, and call progress detection, suitable for operating on unconditioned voice grade telephone lines.
6. Alarm Printer: Listed in UL 1610 and labeled as an integral part of perimeter security system. Dot matrix, with graphics capability, red and black ribbon, and minimum speed of 200 characters per second. Selectable character spacing of 10, 13, or 14 per inch. Tractor drive is suitable for fanfold paper. Furnish 25,000 sheets of printer paper and 12 ribbons.
7. Report Printer: Laser printer, minimum 600 dpi resolution, minimum 2 MB of RAM, and printing speed of 8 pages per minute with 100 sheet automatic feed paper cassette. Furnish 2000 sheets of paper and 5 toner cartridges.
8. Timing Unit: Solid state, programmable, 365 days.
   a. Astronomic Control: For automatic control of light switching at dawn and dusk.
   b. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
   c. Override Capability: Programmed shutdown of lighting and other equipment shall be overridden by using override push buttons or by entering commands over telephone data links.
9. Electrical Power:
   a. Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit shall supply power to all components connected to it, unless otherwise indicated.
   b. Power for Central-Station Control Unit: UPS sized for full load of unit.
   c. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate the system, including audible trouble signal devices for up to six hours and audible and visual alarm devices under alarm conditions for an additional one hour.
   d. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
   e. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

O. Central-Station Control-Unit Software
1. Support:
   a. Multiuser operator with multiple tasks for each user.
   b. Support operation and management of all peripheral devices.
   c. File management functions for disk I/O.
   d. Printer spooling.
   e. Monitor status of UPS.
2. Operator Commands:
   a. Help.
   b. Acknowledge alarm.
   c. Place protected zone in Access.
   d. Place protected zone in Secure.
   e. Protected zone Test.
   f. System Test.
   g. Print Reports.
   h. Change Operator.
   i. Security Lighting Controls.
   j. Display Graphics: Include operator commands as required to meet Project requirements.
   k. Command Input Errors: Supervise inputs to ensure that they are correct for proper execution. Provide automatic help when a command cannot be executed due to operator input error.
3. System Access Control: Define system operator capability and functions through password-protected operations at three operator levels. Allow operator level change only by top-level operators and managers.
   a. Activate tamper alarm after three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period.
   b. Allow at least 32 passwords.
   c. Display operator's name or initials in console's first field.
   d. Report: Print operator's name or initials, action, date, and time on system printer at log-on and log-off. Do not display or print passwords.
   e. Define and assign passwords for the following:
      1) System commands.
      2) Access to system software.
      3) Access to application software.
      4) Individual protected zones to be accessed.
      5) Access to database.
4. Alarm-Monitoring Software: Monitor all sensors, central-station control units, and data transmission circuits and notify operator of an alarm condition. Print alarms in red on alarm printer and display on console's text and graphic maps.
   a. Alarm Display:
      1) Display higher-priority alarms first.
      2) Oldest unacknowledged alarm has highest priority.
      3) Operator acknowledgment of one alarm is not acknowledgment of any other alarm and may not inhibit reporting of subsequent alarms.
      4) Type of alarm, location of alarm, and secondary alarm messages.
      5) Date and time (to nearest second) of occurrence and operator response.
      6) A unique message field with a width of at least 60 characters for each alarm. Allow operator to edit assignment of messages to a protected zone or sensor.
      7) 25 secondary messages shall have a field of 4 lines of 60 characters each to allow further information to be entered by operator for each alarm.
      8) Store most recent 1000 alarms and allow the data to be recalled, but not edited, by operator using the report generator.
5. Monitor Display Software: Display text and graphic maps that integrate protected zone status. Use for various components and real-time data. Use uniform color codes on all displays as follows:

a. FLASHING RED to alert operator that a protected zone has gone into alarm or that primary power has failed.
b. RED to alert operator that a protected zone is in alarm and that alarm has been acknowledged.
c. YELLOW to advise operator that a protected zone is in access.
d. GREEN to indicate that a protected zone is secure or that power is on.

6. System Test Software: Enable operator to initiate a test of entire system or a particular portion of system. Store results of each test for future display, or print them out in report form.
7. Report Generator Software: Commands to generate reports for displaying, printing, and storing on disk and tape. Store reports by type, date, and time and print each on report printer. Provide printer spooling. Generating reports shall not interrupt system operations. Allow operator to select report-generation mode, either periodic automatic or on request. Report headers shall automatically include time and date of printing and name of operator generating the report. Exact format of each report type shall be operator configurable. Allow operator to request, at any time, an immediate printout of any report.
   a. Periodic Automatic Report Modes: Allow for specifying, modifying, or inhibiting the report to be generated, time the initial report is to be generated, time interval between reports, end of period, and output peripheral.
   b. Alarm Report: Include all alarms recorded by the system over an operator-selectable time. Include such information as type of alarm (intrusion, tamper, etc.), type of sensor, location, time, and action taken.
   c. System Test Report: This report documents the operational status of all system components following a system test.
   d. Access and Secure Report: This report documents all protected zones placed in access condition, time placed in access condition, and time placed in secure condition.

P. Audible And Visual Alarm Devices
1. Bell: UL listed, 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from central-station control unit.
   a. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
2. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use - two minutes on, five minutes off.
   a. Designed for use in industrial areas and in high noise, severe weather marine environments.
3. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from central-station control unit.
   a. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
4. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
   a. Light Output: 115 cd, minimum.
   b. Flash Rate: 60 per minute.

Q. Security Fasteners
1. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
2. Drive System Types: Pinned Torx-Plus, pinned Torx, or pinned hex (Allen).
3. Socket Flat Countersunk Head Fasteners:
   a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
   b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
4. Socket Button Head Fasteners:
   a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
   b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
5. Socket Head Cap Fasteners:
   a. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).

b. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.

6. Protective Coatings for Heat-Treated Alloy Steel:
   a. Zinc chromate, ASTM F 1135, Grade 3 or 4; for exterior applications and interior applications where indicated.
   b. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide, unless otherwise indicated.

R. Source Quality Control
1. Electrostatic-Field and Buried, Ported Coaxial Cable Systems Electronics: Precondition at factory by subjecting modules to at least 4 days' operational burn-in at temperatures not less than 140 deg F (60 deg C).

1.3 EXECUTION

A. Installation
1. Security Fasteners: Where accessible to inmates, install perimeter security components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.
2. Wiring Method: Install power, signal, and data transmission wire and cable in raceways according to Division 02 Section(s) "Underground Ducts And Utility Structures" AND Division 16 Section(s) "Raceways And Boxes". Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share raceways with any other system.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with perimeter security system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
4. Wires and Cables:
   a. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
   b. 120-V Power Wiring: Install according to Division 16 Section "Conductors And Cables", unless otherwise indicated.
   c. Cable for Low-Voltage Control and Signal Circuits: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 16 Section "Conductors And Cables For Electronic Safety And Security".
   d. Computer and Data-Processing Cables: Install according to Division 16 Section "Conductors And Cables For Electronic Safety And Security".
   e. Television Signal Transmission Cables: Install according to Division 16 Section "Conductors And Cables For Electronic Safety And Security"
5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
6. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
7. Stain-Sensitive Transducer Cable: Attached to fence at 12-inch (300-mm) intervals with tie wraps.
8. Electrostatic-Field System: Install field and sense wires on insulators and standoffs on a fence, wall, or roof. Provide intermediate supports recommended in writing by manufacturer as needed for specified performance.
9. Buried, Ported Coaxial Cable: Transmitters may be located at one end of parallel coaxial cables, and preamplifier-sensor module may be located at opposite end. Install cable so shield is uniform

throughout the length, without twisting or distorting cable during installation. Field-cut cables to exact zone length at the site. To attach data transmission cable to sensing cable, use heat-shrink splice kits approved by manufacturer. Provide sufficient overlap of detector cables to eliminate the possibility of entry between zones.

10. Identify components with engraved, laminated-plastic or metal nameplate for central-station control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Electrical Identification".

B. Grounding
1. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
3. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 16 Section "Grounding And Bonding".

C. Field Quality Control
1. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
   a. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
3. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
   a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
   b. Operational Tests: Schedule tests after pretesting has been successfully completed. Test all modes of system operation and perimeter security at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.
   c. Electrical Tests: Comply with NFPA 72, Section A-7. Minimum required tests are as follows:
      1) Verify the absence of unwanted voltages between circuit conductors and ground.
      2) Test all conductors for short circuits using an insulation-testing device.
      3) With each circuit pair, short circuit at the far end of circuit and measure circuit resistance with an ohmmeter. Record circuit resistance of each circuit on Record Drawings.
      4) Verify that each controller is in normal condition as detailed in manufacturer's operation and maintenance manual.
      5) Test signal and data transmission circuits complying with requirements in Division 16 Section "Conductors And Cables For Electronic Safety And Security" for proper signal transmission under open-circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
      6) Verify that transient surge-protection devices are installed according to manufacturer's written instructions.
      7) Test each initiating and indicating device for alarm operation and proper response at central-station control unit.
      8) Test both primary and secondary power. Verify, by test, that UPS is capable of operating the system for period and in manner specified.

d. Geophone System Tests: Test each zone at a minimum of two different locations. Test each zone as follows:
   1) Horizontal Movement: Adjust sensitivity to screen out alarms from wind.
   2) Vertical Climb: 100 percent detection required. Set count at 3 occurrences within 90-second window.
   3) Cut Test: 100 percent detection required. Set count at 2 occurrences within 120-second window.
   4) Set sensitivity to value as low as possible, consistent with reliable detection.
   5) If performance tests fail, make adjustments to sensors to comply with requirements. Retest failing and adjacent zones to comply with test.

e. Strain-Sensitive Cable System Tests: Adjust sensitivity and count control to value as low as possible, consistent with reliable detection.

f. Microwave Perimeter Security System Tests: Adjust sensitivity to value as low as possible, consistent with reliable detection.

g. Long-Range PIR System Tests: Adjust sensitivity and hold time between activity duration to value as low as possible, consistent with reliable detection.

4. Report of Tests and Inspections: Prepare a written record of tests, inspections, and detailed test results in the form of a test log.

5. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

D. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain perimeter security.

E. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION 13720

SECTION 13720a - INTRUSION DETECTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for intrusion detection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Intrusion detection with hard-wired and multiplexed, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.

C. Definitions
1. LCD: Liquid-crystal display.
2. LED: Light-emitting diode.
3. PIR: Passive infrared.
4. RFI: Radio-frequency interference.
5. UPS: Uninterruptible power supply.
6. Protected or Protection Zone: A space or area for which an intrusion must be detected and uniquely identified, the sensor or group of sensors assigned to perform the detection, and any interface equipment between sensors and communication link to central-station control unit.
7. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
8. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.

D. Submittals
1. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
a. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers **OR** networks, **as directed,** and control interface devices and media to be used. Describe characteristics of network and other data communication lines.
b. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection and for systems integration. Include designation of devices connected by raceway, raceway type, and size, and type and size of wire and cable fill for each raceway run.
c. UPS: Sizing calculations.
d. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for central-station control-unit console, terminal cabinet, racks, and UPS.
e. Central-Station Control-Unit Console Layout: At 1" = 1'-0" (1:12) scale, showing required artwork and device identification.
f. Device Address List: Coordinate with final system programming.

g. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
h. Details of surge-protection devices and their installation.
i. Sensor detection patterns and adjustment ranges.

3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are not acceptable.
4. Samples: For each type of exposed finish required.
5. Qualification Data: For Installer, intrusion detection systems integrator, and testing agency.
6. Field quality-control test reports.
7. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals. Include the following:
   a. Data for each type of product, including features and operating sequences, both automatic and manual.
   b. Central-station control-unit hardware and software data.
8. Warranty: Special warranty specified in this Section.
9. Other Information Submittals:
   a. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
   b. Examination reports documenting inspections of substrates, areas, and conditions.
   c. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

E. Quality Assurance
1. Installer Qualifications:
   a. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
   b. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
3. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the National Burglar & Fire Alarm Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Owner's insurance underwriter.
   a. Testing Agency's Field Supervisor: Person currently certified as an advanced alarm technician by the National Burglar & Fire Alarm Association to supervise on-site testing specified in Part 3.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. FMG Compliance: FMG-approved and -labeled intrusion detection devices and equipment.
6. Comply with NFPA 70.

F. Project Conditions
1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
   a. Altitude: Sea level to 4000 feet (1220 m).
   b. Central-Station Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.

c. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed,** interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.

d. Interior, Uncontrolled Environment: System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed,** interior environments shall be rated for continuous operation in ambients of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.

e. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick.

f. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

G. Warranty

1. Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within two years from date of Substantial Completion.

1.2 PRODUCTS

A. Functional Description Of System

1. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

   a. Alarm Signal: Display at central-station control unit and actuate audible and visual alarm devices.

   b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.

   c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.

2. System Control: Central-station control unit shall directly monitor intrusion detection units and connecting wiring.

   OR

   System Control: Central-station control unit shall directly monitor intrusion detection devices, perimeter detection units **OR** controllers associated with perimeter detection units, **as directed,** and connecting wiring in a multiplexed distributed control system or as part of a network.

3. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.

4. Operator Commands:

   a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.

   b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.

   c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.

   d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.

   e. Protected Zone Test: Initiate operational test of a specific protected zone.

f. System Test: Initiate system-wide operational test.
g. Print Reports.

5. Timed Control at Central-Station Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
6. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
   a. Switch selected lights.
   b. Shift elevator control to a different mode.
   c. Open a signal path between certain intercommunication stations.
   d. Shift sound system to "listening mode" and open a signal path to certain system speakers.
   e. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.
7. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When central-station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
8. Response Time: Two seconds between actuation of any alarm and its indication at central-station control unit.
9. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from central-station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at central-station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
10. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
11. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

B. System Component Requirements
1. Compatibility: Detection devices and their communication features, connecting wiring, and central-station control unit shall be selected and configured with accessories for full compatibility with existing equipment:
2. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
   a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 16 Section "Transient Voltage Suppression".
   b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 16 Section "Transient Voltage Suppression" as recommended by manufacturer for type of line being protected.
3. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
4. Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.

5. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to central-station control unit.
6. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to central-station control unit as an alarm signal.
7. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to central-station control unit.
8. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at central-station control unit for calibration, sensitivity, and alarm condition.

C. Enclosures
1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
2. Interior Electronics: NEMA 250, Type 12.
3. Exterior Electronics: NEMA 250, Type 4X fiberglass **OR** stainless steel, **as directed**.
4. Corrosion Resistant: NEMA 250, Type 4X PVC **OR** stainless steel, **as directed**.
5. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.

D. Secure And Access Devices
1. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
2. Key-Operated Switch: Change protected zone between secure and access conditions.

E. Door And Window Switches
1. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity. Bias magnet and minimum of two **OR** three, **as directed,** encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.
2. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.
3. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounting magnet and floor-mounting switch unit.
4. Remote Test: Simulate movement of actuating magnet from central-station control unit.

F. PIR Sensors
1. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
   a. Wall-Mounting Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than 50 feet (15 m). Provide adjustable coverage pattern as indicated.
   b. Ceiling-Mounting Unit Spot-Detection Pattern: Full 360-degree conical.
   c. Ceiling-Mounting Unit Pattern Size: 84-inch (2135-mm) diameter at floor level for units mounted 96 inches (2440 mm) above floor; 18-foot (5.5-m) diameter at floor level for units mounted 25 feet (7.6 m) above floor.
2. Device Performance:
   a. Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across 2 adjacent segments of detector's field of view.
   b. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.

c. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

G. Microwave Intrusion Detectors (Interior)

1. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
   a. Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
   b. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
   c. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

H. Acoustic-Type, Glass-Break Sensors

1. Device Performance: Detect unique, airborne acoustic energy spectrum caused by breaking glass.
   a. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern shall be at least a 20-foot (6-m) range.
   b. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
   c. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller or at central-station control unit.
   d. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
   e. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

I. Piezoelectric-Type, Glass-Break Sensors

1. Device Performance: Detect unique, high-frequency vibrations caused by breaking glass.
   a. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to glass surface with adhesive provided by element manufacturer. Circular detection pattern, with at least a 60-inch (1525-mm) radius on a continuous glass pane. Sensor element shall not be larger than 4 sq. in. (25.80 sq. cm).
   b. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).
   c. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller or at central-station control unit.
   d. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
   e. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.

J. Vibration Sensors

1. Description: A sensor controller and piezoelectric crystal sensor elements that are designed to be rigidly mounted to structure being protected.
2. Device Performance: Detects high-frequency vibrations generated by use of such tools as oxyacetylene torches, oxygen lances, high-speed drills and saws, and explosives that penetrate a structure while not responding to any other mechanical vibration.
   a. Circular detection pattern, with at least a 72-inch (1830-mm) radius on protected structure.
   b. Hookup Cable: Factory installed, not less than 72 inches (1830 mm).

c. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
d. Glass-Break Simulator: A device to induce frequencies to protected glass pane that simulate breaking glass without causing damage to glass.

K. Photoelectric Sensors
1. Device Performance: Detect an interruption of a pulsed, infrared, light beam that links transmitter and receiver.
a. Sensitivity: Detect standard-intruder movement within sensor's detection patterns at any speed of less than 7.5 fps (2.3 m/s) though the beam. Allow installation of multiple sensors within same protected zone that will not interfere with each other.
b. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
c. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

L. Microwave-PIR Dual-Technology Motion Sensors
1. Description: Single unit combining a sensor that detects changes in microwave signals and a PIR sensor that detects changes in ambient level of infrared emissions caused by standard-intruder movement within detection pattern.
2. Device Performance: An alarm is transmitted when either sensor detects a standard intruder within a period of three to eight seconds from when the other sensor detects a standard intruder.
a. Minimum Detection Pattern: A room 20 by 30 feet (6 by 9 m).
b. PIR Sensor Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across 2 adjacent segments of detector's field of view.
c. Microwave Sensor Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
d. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
e. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

M. Duress-Alarm Switches
1. Description: A switch with a shroud over the activating lever that allows an individual to covertly send a duress signal to central-station control unit, with no visible or audible indication when activated. Switch shall lock in activated position until reset with a key.
a. Minimum Switch Rating: 50,000 operations.
b. Foot Rail: Foot activated, floor mounting.
c. Push Button: Finger activated, suitable for mounting on horizontal or vertical surface.

N. Video Motion Sensor (Interior)
1. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in EIA 170. Provide an alarm output for each video input.
a. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
b. Modular design that allows for expansion or modification of number of inputs.

c. Controls:
   1) Number of detection zones.
   2) Size of detection zones.
   3) Sensitivity of detection of each protected zone.
d. Mounting: Standard 19-inch (480-mm) rack as described in EIA 310.

O. Central-Station Control Units
1. Description: Panel shall provide supervision of sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
2. Construction: Modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are not acceptable.
3. Comply with UL 609 **OR** UL 1023 **OR** UL 1076, **as directed**.
4. Alarm Indication: Audible signal sounds and a plain-language identification of protected zone originating the alarm appears on LED, LCD, or cathode-ray-tube display at central-station control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.
   a. Alarm activation sounds a bell or siren and strobe.
5. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Include the following:
   a. Acknowledge alarm.
   b. Silence alarm.
   c. System reset.
   d. LED test.
6. Resetting Controls: Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists.
7. Timing Unit: Solid state, programmable, 365 days.
   a. Astronomic Control: For automatic control of light switching at dawn and dusk.
   b. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
   c. Override Capability: Programmed shutdown of lighting and other items shall be overridden by using override push buttons or by entering commands over telephone data links.
8. Alphanumeric Display and System Controls: Arranged for interface between operator and addressable system components, including annunciation and supervision. Display alarm, supervisory, component status messages, and programming and control menu.
   a. Display: LCD, 40 **OR** 80, **as directed,** characters, minimum.
   b. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
9. Alphanumeric Display and System Controls: Arranged for interface between operator at central-station control unit and addressable system components, including annunciation, supervision, and test.
   a. Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into system for testing of sensors.
   b. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
10. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
11. Power Supply Circuits: Central-station control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
12. UPS: Comply with Division 16 Section "Static Uninterruptible Power Supply". UPS shall be sized to provide a minimum of six hours of central-station control-unit operation.

13. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.

P. Annunciator
1. Power and Signal Inputs: From central-station control unit.
2. Visual Displays: Modular-lighted type with displays as indicated and engraved legend for each protected zone annunciated.
3. Light Source: Duplicate LEDs for "alarm signals," visible at a distance of 30 feet (9.2 m).
4. Signals Annunciated: "Secure," "access," and "alarm" shall be distinctly indicated for each protected zone by green, yellow, and red displays, respectively. Annunciate alarm condition by flashing light and steady alarm tone until silence-reset switch is operated.
5. Audible Alarm: Unit mounted within annunciator cabinet; sounds for alarm conditions and is silenced by silence-reset switch on unit. Alarm shall sound again when condition is normalized until silence-reset switch is reset.
6. Silence-Reset Switch: Resets annunciator to normal condition after alarm condition is restored.
7. Test Switch: Tests annunciator LEDs.
8. Cabinet: Two hinged doors, one behind the other. Metal outer door frame with minimum 1/4-inch- (6-mm-) thick, clear acrylic vision lite. Steel inner door with mounting surface for annunciator modules. Both doors shall have flush tumbler locks and tamper switches. Comply with Division 16 Section "Raceways And Boxes".
   a. Graphics: Integrate LED displays with graphic display panel to form a graphic annunciator.
9. Electrical Power: Annunciator shall be powered by UPS of central-station control unit.

Q. Central-Station Control Unit
1. Microprocessor System: Standard personal computer of modular design.
   a. CPU Word Size: 64 bits or larger.
   b. Operating Speed: 500 MHz or faster.
   c. Memory: 258 MB or more.
   d. Ports (Minimum):
      1) Two USB ports.
      2) COM 1 and COM 2.
      3) One enhanced parallel port.
      4) Two serial ports, with adjustable data transmission rates from 9.6 to 57.6 Kbps, selectable in software.
   e. Video Card: Supports at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum rate of 70 Hz.
2. Monitor: Not less than 17 inches (430 mm) with minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm.
3. Keyboard: 101 keys, standard commercial type.
4. Peripherals: Special function keyboards **OR** Touch-screen device, **as directed,** or mouse for frequently used operator commands such as the following:
   a. Help.
   b. Acknowledge alarm.
   c. Place protected zone in Access.
   d. Place protected zone in Secure.
   e. Protected zone Test.
   f. System Test.
   g. Print Reports.
   h. Change Operator.
   i. Security Lighting Controls.
   j. Display Graphics: Include operator commands as required to meet Project requirements.

5. Disk Storage:
   a. Hard disk with controller having a maximum average access time of 10 ms, and a disk with at least 60 gigabytes of formatted storage.
   b. Floppy Disk: Drive and controller for standard 3-1/2-inch high-density diskettes.
   c. Removable Disk Storage: 100 **OR** 250, **as directed,** MB (minimum) drive and controller, with 10 diskettes.
   d. CD-ROM Drive: 40x (minimum) speed, 650 MB Read-Only data storage, 650 MB recording capacity using CD-R technology, with software and 10 CD-R blank disks and 1 test disk.
   e. Modem: 56K, v.90 data/fax with error detection, auto answer/autodial, and call progress detection, suitable for operating on unconditioned voice grade telephone lines.
6. Alarm Printer: Listed in UL 1610 and labeled as an integral part of intrusion detection system. Dot matrix with graphics capability, red and black ribbon, with minimum speed of 200 characters per second. Selectable character spacing of 10, 13, or 14 per inch. Tractor drive is suitable for fanfold paper. Furnish 25,000 sheets of printer paper and 12 ribbons.
7. Report Printer: Laser printer, minimum 600 dpi resolution, minimum 2 MB of RAM, printing speed of 8 pages per minute with 100 sheet automatic feed paper cassette. Furnish 2000 sheets of paper and 5 toner cartridges.
8. Electrical Power:
   a. Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit shall supply power to all components connected to it, unless otherwise indicated.
   b. Power for Central-Station Control Unit: UPS sized for full load of unit.
   c. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate the system, including audible trouble signal devices for up to six hours and audible and visual alarm devices under alarm conditions for an additional one hour.
   d. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
   e. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

R. Central-Station Control-Unit Software
1. Support:
   a. Multiuser operator with multiple tasks for each user.
   b. Support operation and management of all peripheral devices.
   c. File management functions for disk I/O.
   d. Printer spooling.
   e. Monitor status of UPS.
2. Operator Commands:
   a. Help.
   b. Acknowledge alarm.
   c. Place protected zone in Access.
   d. Place protected zone in Secure.
   e. Protected zone Test.
   f. System Test.
   g. Print Reports.
   h. Change Operator.
   i. Security Lighting Controls.
   j. Display Graphics: Include operator commands as required to meet Project requirements.
   k. Command Input Errors: Supervise inputs to ensure that they are correct for proper execution. Provide automatic help when a command cannot be executed due to operator input error.

3. System Access Control: Define system operator capability and functions through password-protected operations at three operator levels. Allow operator level change only by top-level operators and managers.
   a. Activate tamper alarm after three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period.
   b. Allow at least 32 passwords.
   c. Display operator's name or initials in console's first field.
   d. Report: Print operator's name or initials, action, date, and time on system printer at log-on and log-off. Do not display or print passwords.
   e. Define and assign passwords for the following:
      1) System commands.
      2) Access to system software.
      3) Access to application software.
      4) Individual protected zones to be accessed.
      5) Access to database.
4. Alarm-Monitoring Software: Monitor all sensors, central-station control units, UPS, and data transmission circuits and notify operator of an alarm condition. Print alarms in red on alarm printer and display on console's text and graphic maps.
   a. Alarm Display:
      1) Display higher-priority alarms first.
      2) Oldest unacknowledged alarm has highest priority.
      3) Operator acknowledgment of one alarm is not acknowledgment of any other alarm and may not inhibit reporting of subsequent alarms.
      4) Type of alarm, location of alarm, and secondary alarm messages.
      5) Date and time (to nearest second) of occurrence and operator response.
      6) A unique message field with a width of at least 60 characters for each alarm. Allow operator to edit assignment of messages to a protected zone or sensor.
      7) 25 secondary messages shall have a field of 4 lines of 60 characters each to allow further information to be entered by operator for each alarm.
      8) Store most recent 1000 alarms and allow the data to be recalled, but not edited, by operator using the report generator.
5. Monitor Display Software: Display text and graphic maps that integrate protected zone status. Use for various components and real-time data. Use uniform color codes on all displays as follows:
   a. FLASHING RED to alert operator that a protected zone has gone into alarm or that primary power has failed.
   b. RED to alert operator that a protected zone is in alarm and that alarm has been acknowledged.
   c. YELLOW to advise operator that a protected zone is in access.
   d. GREEN to indicate that a protected zone is secure or that power is on.
6. System Test Software: Enable operator to initiate a test of entire system or a particular portion of system. Store results of each test for future display, or print them out in report form.
7. Report Generator Software: Commands to generate reports for displaying, printing, and storing on disk and tape. Store reports by type, date, and time and print each on report printer. Provide printer spooling. Generating reports shall not interrupt system operations. Allow operator to select report-generation mode, either periodic automatic or on request. Report headers shall automatically include time and date of printing and name of operator generating the report. Exact format of each report type shall be operator configurable. Allow operator to request, at any time, an immediate printout of any report.
   a. Periodic Automatic Report Modes: Allow for specifying, modifying, or inhibiting the report to be generated, time the initial report is to be generated, time interval between reports, end of period, and output peripheral.
   b. Alarm Report: Include all alarms recorded by the system over an operator-selectable time. Include such information as type of alarm (intrusion, tamper, etc.), type of sensor, location, time, and action taken.

c. System Test Report: This report documents the operational status of all system components following a system test.
d. Access and Secure Report: This report documents all protected zones placed in access condition, time placed in access condition, and time placed in secure condition.

S. Audible And Visual Alarm Devices
1. Bell: Central-station control unit 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from central-station control unit.
a. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
2. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.
a. Designed for use in industrial areas and in high noise, severe weather marine environments.
3. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from central-station control unit.
a. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
4. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
a. Light Output: 115 cd, minimum.
b. Flash Rate: 60 per minute.

T. Security Fasteners
1. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
2. Drive System Types: Pinned Torx-Plus, Pinned Torx or pinned hex (Allen).
3. Socket Flat Countersunk Head Fasteners:
a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
4. Socket Button Head Fasteners:
a. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
b. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
5. Socket Head Cap Fasteners:
a. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
b. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
6. Protective Coatings for Heat-Treated Alloy Steel:
a. Zinc chromate, ASTM F 1135, Grade 3 or 4; for exterior applications and interior applications where indicated.
b. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide, unless otherwise indicated.

1.3 EXECUTION

A. System Installation
1. Comply with UL 681 **OR** UL 1641, **as directed**.
2. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.

B. Wiring Installation
1. Wiring Method: Install wiring in metal raceways according to Division 16 Section "Raceways And Boxes". Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size

shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.

2. Wiring Method: Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
3. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
5. Wires and Cables:
   a. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
   b. 120-V Power Wiring: Install according to Division 16 Section "Conductors And Cables", unless otherwise indicated.
   c. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 16 Section "Conductors And Cables For Electronic Safety And Security".
   d. Computer and Data-Processing Cables: Install according to Division 16 Section "Conductors And Cables For Electronic Safety And Security".
   e. Television Signal Transmission Cables: Install according to Division 16 Section "Conductors And Cables For Electronic Safety And Security".
6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
7. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
8. Identify components with engraved, laminated-plastic or metal nameplate for central-station control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Electrical Identification".

C. Grounding
1. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
3. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 16 Section "Grounding And Bonding".

D. Field Quality Control
1. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
   a. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

3. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
   a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
   b. Operational Tests: Schedule tests after pretesting has been successfully completed. Test all modes of system operation and intrusion detection at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.
   c. Electrical Tests: Comply with NFPA 72, Section A-7. Minimum required tests are as follows:
      1) Verify the absence of unwanted voltages between circuit conductors and ground.
      2) Test all conductors for short circuits using an insulation-testing device.
      3) With each circuit pair, short circuit at the far end of circuit and measure circuit resistance with an ohmmeter. Record circuit resistance of each circuit on Record Drawings.
      4) Verify that each controller is in normal condition as detailed in manufacturer's operation and maintenance manual.
      5) Test signal and data transmission circuits complying with requirements in Division 16 Section "Conductors And Cables For Electronic Safety And Security" for proper signal transmission under open-circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
      6) Verify that transient surge-protection devices are installed according to manufacturer's written instructions.
      7) Test each initiating and indicating device for alarm operation and proper response at central-station control unit.
      8) Test both primary and secondary power. Verify, by test, that UPS is capable of operating the system for period and in manner specified.
4. Report of Tests and Inspections: Prepare a written record of tests, inspections, and detailed test results in the form of a test log.
5. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

E. Demonstration
   1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain intrusion detection.

F. Adjusting
   1. Occupancy Adjustments: When requested within 12 months of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION 13720a

SECTION 13810 - CLOCK AND PROGRAM CONTROL

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for clock and program control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
2. Master clock and program control unit.
3. Secondary indicating clocks.
4. Program signal devices.
5. Clock circuit power boosters.
6. Interface with intercom and public-address system.
7. System wire and cable.

C. Definitions
1. NIST: The National Institute of Science and Technology.
2. PC: Personal computer.
3. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

D. Performance Requirements
1. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual.
2. Shop Drawings: For clock systems. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring and correction circuits.
      1) Identify terminals and wiring color codes to facilitate installation, operation, and maintenance.
      2) Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from overcurrent, static discharge, and voltage surge.
   b. Details of seismic restraints including mounting, anchoring, and fastening devices for the following system components:
      1) Surface-mounted and semirecessed secondary indicating clocks.
      2) Master clock enclosures **OR** mounting racks, **as directed**.
      3) Clock circuit power boosters.
   c. Details of seismic strengthening of master clock enclosures **OR** mounting racks, **as directed**.

d. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.

3. Delegated-Design Submittal: For the master clock and housing indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Detail fabrication and assembly of the master clock and housing.
   b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Seismic Qualification Certificates: For the master clock, accessories, and components, from manufacturer.
5. Field quality-control reports.
6. Operation and maintenance data.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Master And Secondary Clock System
1. System Functions and Features:
   a. Supply power to remote indicating clocks except those indicated to have correction signals applied through a data circuit.
   b. Maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any one **OR** two, **as directed**, type(s) of secondary indicating clocks, including the following:
      1) Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
      2) Digital Clocks: Test clocks automatically for synchronization with master time control at least once every hour and automatically correct those not synchronized with the time reference unit. Automatically correct clocks immediately when power is restored after an outage of power to the master clock.
   c. Initiate and execute programs for scheduled automatic operation of remote devices. Include audible signal devices and visual signal devices, **as directed**, and on and off switching of equipment and circuits, **as directed**.
   d. Provide for manual control of programmed signal and equipment-switching circuits.
   e. Communicate with remote PC for access to UTC time base and to permit programming from remote location, **as directed**.
   f. Maintain system access security with a minimum of one level **OR** two levels **OR** three levels, **as directed**, of user-access control to restrict use of system controls to authorized personnel. Levels of access apply to both local access and access from a remote computer, **as directed**. Access to user programming and control functions is accomplished by entering a minimum three-digit code. Access levels include the following:
      1) Access to review existing programs only.
      2) Access to normal system operating controls.
      3) Access to all user-programming and control functions.
   g. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.
      OR
      Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator, and automated periodic reference to NIST or UTC time signals via internal telephone modem and automatic dialup connection **OR** internal modem and network or microcomputer Internet

access **OR** dedicated internal radio receiver tuned to NIST time signal broadcasts, **as directed**. Reference time signals shall be automatically accessed at programmable intervals.

h. Provide for programming multiple independent event schedules into memory and running them simultaneously for different output circuits.
   1) Quantity of Programmable Schedules: Three **OR** Four **OR** Eight **OR** 18 **OR** 250, **as directed**, minimum.
   2) Number of Weekly Events That Can Be Programmed for Each Schedule: 64 **OR** 128 **OR** 300 **OR** 600 **OR** 2500, **as directed**, minimum.
   3) Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
   4) Advance Programming for Automatic Holiday Schedule Changes: Number of schedule changes that can be programmed to suit holidays and vacations shall be 10 **OR** 16 **OR** 50 **OR** 100, **as directed**, and each change may be programmed up to a year in advance to occur on any day of the calendar year.

i. Automatically check functioning of LEDs, switches, input keys, central processor, read-only memory, random access memory, and output circuits. A display on the control panel or a remote computer with the proper access code, **as directed**, shall indicate failure by identifying faulty component or circuit and shall recommend corrective action.

j. Provide manually initiated **OR** programming for automatic, **as directed**, daylight savings time correction.

k. Provide for adjustments to master clock output signals. Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 99 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

B. Master Clock

1. Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15.
   a. Programming and control switches.
   b. Informational Display: LED or backlit LCD type.
      1) Normally shows current time, date, and day of week, **as directed**, display.
      2) Provides programming cues when system is being programmed.
   c. Output Circuits for Power and Correction of Secondary Indicating Clocks:
      1) Wired Synchronous Clock Power-and-Correction Circuits: For analog and digital, **as directed**, clocks; a minimum of one **OR** two, **as directed**, required. Relay controlled.
         OR
         Wired Synchronous Digital Clock Power-and-Correction Circuits: One, **as directed**, required.
      2) Existing Clock Power-and-Correction Circuit: An output circuit suitable for the of existing power-and-correction circuit and number of clocks to be connected.
   d. Data Output Port for Digital, **as directed**, Secondary Clock Correction Circuit: RS485 or similar circuit for scheduled periodic correction signals.
   e. Modem and PC interface software suitable for remote programming and automatic NIST or UTC synchronization, **as directed**.
   f. Circuits for Audible and Visual, **as directed**, Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, five **OR** 10, **as directed,** A minimum. A minimum of two **OR** four **OR** six **OR** eight, **as directed**, circuits.
   g. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, 5 **OR** 10, **as directed**, A minimum. A minimum of two **OR** four **OR** six **OR** eight, **as directed**, circuits.
   h. Power Supplies: Capacity for internal loads and power-and correction circuits of connected clocks.

i. Enclosure: Metal cabinet with locking front panel. When cabinet is locked, display indication shall be visible on or through front panel face. Arrange cabinet for surface, semirecessed, or flush mounting as indicated.
OR
Housing: Rack-mounting metal enclosure with display indication visible on front panel face.
1) Reinforce mounting and attachment capable of resisting seismic forces described in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

j. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal ac power supply for up to 10 years.

k. Electrostatic Discharge Resistance: Master clock and secondary indicating clocks, **as directed**, shall be tested and certified according to IEC 61000-4-2 in both human-discharge and direct-injection modes.

C. Secondary Indicating Clocks

1. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.

2. Digital Clock: Microprocessor-controlled unit complying with Class A device requirements in 47 CFR 15, with red LED digital time display of hours and minutes **OR**, minutes, and seconds, **as directed**.

a. Display Height: 2-1/2-Inch (64-mm) Clock: Hour and minute numerals readable at 50 feet (15 m).
OR
Display Height: 4-Inch (102-mm) Clock: Hour and minute numerals readable at 100 feet (30 m).

b. Display Format: Selectable between 12-hour with "PM" LED display and 24-hour formats.

c. Connections for Power and Correction:
1) Wired synchronous connection to the master clock for both operating power and correction.
a) Time-Base Backup: Internal alkaline battery shall back up internal time base to maintain timekeeping during power outages of up to six days' duration.
OR
Time-Base Backup: Internal capacitor shall back up internal time base to maintain timekeeping during power outages of up to 12 hours' duration.
b) Correction by RS485, Ethernet, or similar data line with operating power supplied over a separate connection.
c) Power Connection for Secondary Indicating Clocks: Plug connector **OR** Wire pigtail or compression splice, **as directed**.

3. Interval-Timer Clock: Digital microprocessor-controlled, 4-inch (102-mm) unit with 2-1/2-inch (64-mm), red LED digital display for hours and minutes and 1-5/16-inch (33-mm) display for seconds; a separately mounted, mode-control switch; and the following features:

a. Display Visibility: Hour and minute numerals readable at 30 feet (10 m) in normal ambient light.

b. Operating Modes:
1) Normal: Clock operates as a regular secondary system clock, displaying corrected time in normal display configuration, selectable between 12- and 24-hour formats, with "PM" digital display for 12-hour format.
2) Count-Down or Count-Up Timer: Selected by mode-control switch count-up and count-down positions, and capable of being preset at the mode-control station.
3) Code Blue: Automatically selected by a signal through a wiring connection from the code-blue system. This signal captures control of the clock regardless of current mode or correction status and instantly initiates count-up operation, starting at time 00:00:00. While in this mode, other clock functions, including correction, shall run in

the background. Clock shall revert to normal operating mode when the initiating-signal system is reset.

c. Mode-Selector Switch: Push-button or rotary, multiposition type, flush mounted; with start, stop, and reset capability in both count-up and count-down modes.

d. Audible tone signal: Housed in clock or mode-selector-switch box. Sounds at end of preset up or down count.

4. Provision for Modular Panel Installation: Equip designated clock for panel mounting. Mount flush or semirecessed with arrangement and trim as indicated. Coordinate wiring with other modular panel components, including room lighting switches **OR** intercom devices **OR** convenience outlets **OR** data outlets **OR** speaker **OR** other similar devices, **as directed**.

5. Provision for Time-Tone-Unit Installation: Equip indicated clocks for housing or mounting in an acoustically treated and baffled speaker compartment specified in Division 16 Section "Public Address And Mass Notification Systems".

D. Secondary Indicating Clock Characteristics:

a. Clock Type: Analog **OR** Digital, **as directed**.

b. Face Configuration: Single **OR** Double, **as directed**.

c. Mounting: Recessed **OR** Semirecessed **OR** Pendant **OR** Surface **OR** Suspended **OR** Within time-tone unit **OR** Within modular panel, **as directed**.

d. Nominal Dimensions: as directed by the Owner.

e. Casing Finish: Types and colors, as directed by the Owner.

f. Special Environmental Conditions: Describe conditions such as corrosive, damp, or wet locations, as directed by the Owner.

g. For analog clocks.

1) Dial Face Color: as directed by the Owner.

2) Analog Clock Crystal: Clear glass **OR** acrylic **OR** polycarbonate, **as directed**.

h. For digital clocks.

1) Face Color: as directed by the Owner.

2) Display Height: as directed by the Owner.

3) Seconds Display: Yes **OR** No, **as directed**.

4) Digital Clock Lens: Antiglare acrylic material.

5) Battery Backup: Yes **OR** No, **as directed**.

6) Interval-Timer Display: Yes **OR** No, **as directed**.

E. Program Signal Devices

1. Bells: Heavy-duty, modular, vibrating type with the following sound-output ratings measured at 10 feet (3 m):

a. 4-Inch (100-mm) Bell: 90 dB.

b. 6-Inch (150-mm) Bell: 95 dB.

c. 10-Inch (250-mm) Bell: 104 dB.

2. Chimes: Heavy-duty, modular, vibrating chimes with polished-chrome tone bar and enamel-finished housing. Minimum sound-output rating measured at 10 feet (3 m) shall be 75 dB.

3. Clock Buzzers: Adjustable output signal device designed for mounting within clock housing or outlet box.

a. Sound-Output Rating Measured at 3 Feet (1 m): 75 dB.

b. Audible Tone Frequency: Manufacturer's standard between 120 Hz and 2 kHz.

4. Horns: Modular, adjustable-output, vibrating type with minimum full-intensity-rated sound output of 103 dB measured at 10 feet (3 m).

5. Projector Horns: Adjustable-output, vibrating type with single **OR** double, **as directed**, projector arranged to channel sound in the direction of the projector axis, and with minimum full-intensity-rated sound output of 104 dB measured at 10 feet (3 m).

6. Loudspeakers for Audible Tones: See Division 16 Section "Public Address And Mass Notification Systems".

7. Visible Signal Devices: Strobe lights with blue **OR** yellow, **as directed**, polycarbonate lens and xenon flash tube, with lens mounted on an aluminum faceplate and the word "Program" engraved

in letters at least 1 inch (25 mm) high on lens. Lamp unit shall have a minimum rated light output of 75 candela.

8. Combination Audible and Visible Signal Devices: Factory-integrated horn and strobe light in a single mounting assembly.
9. Outdoor Signal Equipment: Weatherproof models listed for outdoor use.
10. Mounting Arrangement for Signal Devices: Designed for attachment with screws on the mounting plate of a flush-mounted back box unless otherwise indicated.
11. Enclosures for Flush-Mounting Bells and Horns: Enclosure, mounting plate, and grille assembly shall be furnished by device manufacturer to match features of the device to be mounted. Enclosure shall be recessed in wall, completely enclosing the device, with grille mounting over the open side of the enclosure and flush with the wall.
12. Connection Provision for Signal-Indicating Devices: Plug connector **OR** Wire pigtail or compression splice, **as directed**.

F. Clock Circuit Power Booster
1. Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.

G. Back Boxes For Secondary Indicating Clocks And Program Devices
1. Description: Box and cover-plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting the device unless otherwise indicated.

H. Guards
1. Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.
   a. Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
   b. Finish for Indoor Devices: Clear epoxy lacquer over zinc plating.
   c. Finish for Outdoor Devices: Black powder coat over zinc plating and primer.

I. Rack-Mounting Provision For Master Clock
1. Equipment Cabinet: Floor **OR** Wall, **as directed**,-mounted, rack type. Comply with EIA-310-D and the following:
   a. Cabinet Housing: Constructed of steel, with front and rear, **as directed**, doors; with manufacturer's standard tumbler locks, keyed alike.
      1) Front door shall have a clear panel in front of the master clock display.
      2) Housing shall enclose master clock and auxiliary clock system components, plus a minimum of 20 percent spare capacity for future equipment.
   b. Forced Ventilation: Internal low-noise fan with a filtered intake vent, connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switchable and arranged to be powered when main cabinet power switch is on.
      OR
      Natural Ventilation: Ventilated rear and sides with louvers and solid top.
   c. For freestanding, floor-mounting cabinet, arrange inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
   d. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by equipment or panels.
   e. Finish: Uniform, baked-enamel, manufacturer's standard color finish over rust-inhibiting primer.
   f. Power-Control Panel: On front of equipment housing; with master power on-off switch and pilot light, and socket for a 5-A, indicating, cartridge fuse for rack equipment power.
   g. Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c. the full height of rack, to supply rack-mounting equipment.

h. Maintenance Receptacles: Duplex convenience outlet with supply terminals separate from equipment plug strip and located in front of rack.

J. Conductors And Cables
1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions. Comply with requirements in Division 16 Section "Communications Horizontal Cabling".
2. 120-V AC and Class 1 Signal and Control Circuits: Stranded, single conductors of size and type recommended by system manufacturer. Materials and installation requirements are specified in Division 16 Section "Conductors And Cables".
3. Class 2 and Class 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable.
4. Data Circuits: Category 6 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.
5. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
6. Plenum Cable: Listed and labeled for plenum installation.
7. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.
8. Shielding: For speaker-microphone leads and at other locations recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.
   a. Minimum Shielding Coverage on Conductors: 60 percent.

K. Pathways
1. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes".
   OR
   Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 16 Section "Raceways And Boxes".
   OR
   Intercommunication and Program System Raceways and Boxes: Optical fiber/communications raceway and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
2. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
3. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Installation
1. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

B. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways And Boxes".
   OR
   Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

2. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
3. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA/EIA-568-B.

C. Electrical Connections
1. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
2. Use plug connectors **OR** splices, **as directed**, for connections to clocks and signal devices.
3. Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Identification
1. Comply with Division 16 Section "Electrical Identification".
2. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

E. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
   b. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
3. Clock system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

F. Adjusting
1. Program system according to Owner's requirements. Set system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.
2. Adjust sound-output level of adjustable signal devices to suit Owner's requirements.
3. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components.

END OF SECTION 13810

SECTION 13852 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for digital, addressable fire alarm system. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fire-alarm control unit.
b. Manual fire-alarm boxes.
c. System smoke detectors.
d. Nonsystem smoke detectors.
e. Heat detectors.
f. Notification appliances.
g. Firefighters' two-way telephone communication service.
h. Magnetic door holders.
i. Remote annunciator.
j. Addressable interface device.
k. Digital alarm communicator transmitter.
l. Radio alarm transmitter.
m. System printer.

C. Definitions
1. LED: Light-emitting diode.
2. NICET: National Institute for Certification in Engineering Technologies.

D. System Description
1. Noncoded, UL-certified **OR** FMG-placarded, **as directed**, addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.
2. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

E. Performance Requirements
1. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed.**

F. Submittals
1. General Submittal Requirements:
a. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Owner.
b. Shop Drawings shall be prepared by persons with the following qualifications:
1) Trained and certified by manufacturer in fire-alarm system design.
2) NICET-certified fire-alarm technician, Level III **OR** Level IV, **as directed**, minimum.
3) Licensed or certified by authorities having jurisdiction.
2. Product Data: For each type of product indicated.
3. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

a. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
b. Include voltage drop calculations for notification appliance circuits.
c. Include battery-size calculations.
d. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
e. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
f. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
g. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

4. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
   b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
5. Qualification Data: For qualified Installer.
6. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control reports.
8. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. Deliver copies to authorities having jurisdiction and include the following:
   a. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   b. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   c. Record copy of site-specific software.
   d. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
      1) Frequency of testing of installed components.
      2) Frequency of inspection of installed components.
      3) Requirements and recommendations related to results of maintenance.
      4) Manufacturer's user training manuals.
   e. Manufacturer's required maintenance related to system warranty requirements.
   f. Abbreviated operating instructions for mounting at fire-alarm control unit.
   g. Copy of NFPA 25.
9. Software and Firmware Operational Documentation:
   a. Software operating and upgrade manuals.
   b. Program Software Backup: On magnetic media or compact disk, complete with data files.
   c. Device address list.
   d. Printout of software application and graphic screens.

G. Quality Assurance
1. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
2. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II **OR** Level III **OR** Level IV, **as directed**, technician.
3. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL.
6. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.
7. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FMG-approved alarm company.
8. NFPA Certification: Obtain certification according to NFPA 72 by agency having jurisdiction.

H. Project Conditions
1. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-alarm service.
   b. Do not proceed with interruption of fire-alarm service without the Owner written permission.

I. Sequencing And Scheduling
1. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
2. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

J. Software Service Agreement
1. Comply with UL 864.
2. Technical Support: Beginning with Substantial Completion, provide software support for two years.
3. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   a. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Systems Operational Description
1. Fire-alarm signal initiation shall be by one or more of the following devices and systems, **as directed**:
   a. Manual stations.
   b. Heat detectors.
   c. Flame detectors.
   d. Smoke detectors.
   e. Duct smoke detectors.
   f. Verified automatic alarm operation of smoke detectors.
   g. Automatic sprinkler system water flow.

h. Heat detectors in elevator shaft and pit.
i. Fire-extinguishing system operation.
j. Fire standpipe system.

2. Fire-alarm signal shall initiate the following actions:
   a. Continuously operate alarm notification appliances.
   b. Identify alarm at fire-alarm control unit and remote annunciators, **as directed**.
   c. Transmit an alarm signal to the remote alarm receiving station.
   d. Unlock electric door locks in designated egress paths.
   e. Release fire and smoke doors held open by magnetic door holders.
   f. Activate voice/alarm communication system.
   g. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
   h. Activate smoke-control system (smoke management) at firefighter smoke-control system panel.
   i. Activate stairwell and elevator-shaft pressurization systems.
   j. Close smoke dampers in air ducts of designated air-conditioning duct systems.
   k. Recall elevators to primary or alternate recall floors.
   l. Activate emergency lighting control.
   m. Activate emergency shutoffs for gas and fuel supplies.
   n. Record events in the system memory.
   o. Record events by the system printer.
3. Supervisory signal initiation shall be by one or more of the following devices and actions:
   a. Valve supervisory switch.
   b. Low-air-pressure switch of a dry-pipe sprinkler system.
   c. Elevator shunt-trip supervision.
4. System trouble signal initiation shall be by one or more of the following devices and actions:
   a. Open circuits, shorts, and grounds in designated circuits.
   b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
   c. Loss of primary power at fire-alarm control unit.
   d. Ground or a single break in fire-alarm control unit internal circuits.
   e. Abnormal ac voltage at fire-alarm control unit.
   f. Break in standby battery circuitry.
   g. Failure of battery charging.
   h. Abnormal position of any switch at fire-alarm control unit or annunciator.
   i. Fire-pump power failure, including a dead-phase or phase-reversal condition.
   j. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.
5. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators, **as directed**. Record the event on system printer.

B. Fire-Alarm Control Unit
1. General Requirements for Fire-Alarm Control Unit:
   a. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
      1) System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
      2) Include a real-time clock for time annotation of events on the event recorder and printer.
   b. Addressable initiation devices that communicate device identity and status.
      1) Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit, **as directed**.
      2) Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
   c. Addressable control circuits for operation of mechanical equipment.

2. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
   a. Annunciator and Display: Liquid-crystal type, 1 **OR** 2 **OR** 3, **as directed**, line(s) of 40 **OR** 80, **as directed**, characters, minimum.
   b. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters, **as directed**.
3. Circuits:
   a. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
      1) Initiating Device Circuits: Style D **OR** Style E, **as directed**.
      2) Notification Appliance Circuits: Style Z.
      3) Signaling Line Circuits: Style 2 **OR** Style 5 **OR** Style 6 **OR** Style 7, **as directed**.
      4) Install no more than 50 addressable devices on each signaling line circuit.
   b. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.
      1) Initiating Device Circuits: Style A **OR** Style B **OR** Style C, **as directed**.
      2) Notification Appliance Circuits: Style W **OR** Style X **OR** Style Y, **as directed**.
      3) Signaling Line Circuits: Style 0.5 **OR** Style 1 **OR** Style 3 **OR** Style 3.5 **OR** Style 4 **OR** Style 4.5, **as directed**.
      4) Install no more than 50 addressable devices on each signaling line circuit.
   c. Serial Interfaces: Two RS-232 ports for printers.
4. Stairwell Pressurization: Provide an output signal using an addressable relay to start the stairwell pressurization system. Signal shall remain on until alarm conditions are cleared and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.
   a. Pressurization starts when any alarm is received at fire-alarm control unit.
   b. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.
5. Smoke-Alarm Verification:
   a. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
   b. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
   c. Record events by the system printer.
   d. Sound general alarm if the alarm is verified.
   e. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
6. Notification Appliance Circuit: Operation shall sound in a <**Insert pattern**>.
7. Elevator Recall:
   a. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall, **as directed**.
      1) Elevator lobby detectors except the lobby detector on the designated floor.
      2) Smoke detector in elevator machine room.
      3) Smoke detectors in elevator hoistway.
   b. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
   c. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
      1) Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.
8. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be **OR** not be, **as directed**, connected to fire-alarm system.
9. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-

adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

10. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
11. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center **OR** as a special module that is part of fire-alarm control unit, **as directed**.
    a. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
        1) Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
        2) Programmable tone and message sequence selection.
        3) Standard digitally recorded messages for "Evacuation" and "All Clear."
        4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.
    b. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
    c. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
12. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
13. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals **OR** supervisory and digital alarm communicator transmitters **OR** digital alarm radio transmitters, **as directed**, shall be powered by 24-V dc source.
    a. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
14. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
    a. Batteries: Sealed lead calcium **OR** Sealed, valve-regulated, recombinant lead acid **OR** Vented, wet-cell pocket, plate nickel cadmium, **as directed**.
15. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

C. Manual Fire-Alarm Boxes
1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
    a. Single-action mechanism, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
    b. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

c. Station Reset: Key- or wrench-operated switch.
d. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
e. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

D. System Smoke Detectors
1. General Requirements for System Smoke Detectors:
a. Comply with UL 268; operating at 24-V dc, nominal.
b. Detectors shall be four **OR** two, **as directed**,-wire type.
c. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
d. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
e. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
f. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
g. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
1) Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
2) Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
3) Provide multiple levels of detection sensitivity for each sensor.
2. Photoelectric Smoke Detectors:
a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).
3. Ionization Smoke Detector:
a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
1) Primary status.
2) Device type.
3) Present average value.
4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).
4. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
1) Primary status.
2) Device type.
3) Present average value.

4) Present sensitivity selected.
5) Sensor range (normal, dirty, etc.).

c. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
d. Each sensor shall have multiple levels of detection sensitivity.
e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
f. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

E. Nonsystem Smoke Detectors

1. Single-Station Smoke Detectors:
   a. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device, **as directed**.
   b. Auxiliary Relays: One Form C rated at 0.5 A **OR** Form A and one Form C, both rated at 0.5 A, **as directed**.
   c. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
   d. Visible Notification Appliance: 177-cd strobe.
   e. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise, **as directed**, and fixed temperature.
   f. Test Switch: Push to test; simulates smoke at rated obscuration.
   g. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
   h. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
   i. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
   j. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
2. Single-Station Duct Smoke Detectors:
   a. Comply with UL 268A; operating at 120-V ac.
   b. Sensor: LED or infrared light source with matching silicon-cell receiver.
      1) Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) when tested according to UL 268A.
   c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
      1) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
   d. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
   e. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

F. Heat Detectors

1. General Requirements for Heat Detectors: Comply with UL 521.
2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
   a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
   b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

3. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).
   a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
   b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Continuous Linear Heat-Detector System:
   a. Detector Cable: Rated detection temperature 155 deg F (68 deg C). NRTL listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short- circuit wires at the location of elevated temperature.
   b. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
   c. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
   d. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

G. Notification Appliances
1. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
2. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
   a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
3. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
4. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
5. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.
6. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
   a. Rated Light Output:
      1) 15 **OR** 30 **OR** 75 **OR** 110 **OR** 177, **as directed**, cd.
         OR
         15/30/75/110 cd, selectable in the field.
   b. Mounting: Wall mounted unless otherwise indicated.
   c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   d. Flashing shall be in a temporal pattern, synchronized with other units.
   e. Strobe Leads: Factory connected to screw terminals.
   f. Mounting Faceplate: Factory finished, red **OR** white, **as directed**.
7. Voice/Tone Notification Appliances:
   a. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
   b. High-Range Units: Rated 2 to 15 W.
   c. Low-Range Units: Rated 1 to 2 W.
   d. Mounting: Flush **OR** Semirecessed **OR** Surface mounted and bidirectional, **as directed**.

e. Matching Transformers: Tap range matched to acoustical environment of speaker location.

H. Firefighters' Two-Way Telephone Communication Service
1. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit, the fire command center, **as directed**, and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:
   a. Common-talk type for firefighter use only.
   b. Selective-talk type for use by firefighters and fire wardens.
   c. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.
   d. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.
   e. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
   f. Display: Graphic **OR** Liquid-crystal digital, **as directed**, to indicate location of caller.
   g. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
      1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Warden Phone" **OR** "Fire Emergency Phone", **as directed.**
      2) With "break-glass" type door access lock.
   h. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Warden Phone" **OR** "Fire Emergency Phone", **as directed.**
   i. Handsets: <**Insert number**> push-to-talk-type sets with noise-canceling microphone, **as directed**, stored in a cabinet adjacent to fire-alarm control unit **OR** in the fire command center, **as directed**.

I. Magnetic Door Holders
1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
   a. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
   b. Wall-Mounted Units: Flush mounted unless otherwise indicated.
   c. Rating: 24-V ac or dc.
   d. Rating: 120-V ac.
2. Material and Finish: Match door hardware.

J. Remote Annunciator
1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
   a. Mounting: Flush **OR** Surface, **as directed**, cabinet, NEMA 250, Type 1.
2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

K. Addressable Interface Device
1. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
2. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall **OR** to circuit-breaker shunt trip for power shutdown, **as directed**.

L. Digital Alarm Communicator Transmitter

1. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
2. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one **OR** two, **as directed**, telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either, **as directed**, line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
3. Local functions and display at the digital alarm communicator transmitter shall include the following:
   a. Verification that both telephone lines are available.
   b. Programming device.
   c. LED display.
   d. Manual test report function and manual transmission clear indication.
   e. Communications failure with the central station or fire-alarm control unit.
4. Digital data transmission shall include the following:
   a. Address of the alarm-initiating device.
   b. Address **OR** Zone, **as directed**, of the supervisory signal.
   c. Address **OR** Zone, **as directed**, of the trouble-initiating device.
   d. Loss of ac supply or loss of power.
   e. Low battery.
   f. Abnormal test signal.
   g. Communication bus failure.
5. Secondary Power: Integral rechargeable battery and automatic charger.
6. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

M. Radio Alarm Transmitter
1. Transmitter shall comply with NFPA 1221 and shall be listed and labeled by an NRTL.
2. Comply with 47 CFR 90.
3. Description: Manufacturer's standard commercial product; factory assembled, wired, tested, and ready for installation and operation.
   a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
   b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
   c. Normal Power Input: 120-V ac.
   d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
   e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph (160 km/h), **as directed**, with a gust factor of 1.3 without failure.
   f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
   g. Antenna-Cable Connectors: Weatherproof.
   h. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
4. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-

reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:

a. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
b. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
c. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
d. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
e. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
f. Local Fire-Alarm-System Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm, **as directed**.

N. System Printer
1. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

O. Device Guards
1. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
a. Factory fabricated and furnished by manufacturer of device.
b. Finish: Paint of color to match the protected device.

1.3 EXECUTION

A. Equipment Installation
1. Comply with NFPA 72 for installation of fire-alarm equipment.
2. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches (1830 mm) above the finished floor. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
a. Install seismic bracing. Comply with requirements in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
a. Comply with requirements for seismic-restraint devices specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
a. Comply with requirements for seismic-restraint devices specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
5. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
a. Connect new equipment to existing control panel in existing part of the building.
b. Connect new equipment to existing monitoring equipment at the supervising station.

c. Expand, modify, and supplement existing control **OR** monitoring, **as directed**, equipment as necessary to extend existing control **OR** monitoring, **as directed**, functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

6. Smoke- or Heat-Detector Spacing:
   a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
   b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
   c. Smooth ceiling spacing shall not exceed 30 feet (9 m)
   d. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
   e. HVAC: Locate detectors not closer than 3 feet (1 m) **OR** 5 feet (1.5 m), **as directed**, from air-supply diffuser or return-air opening.
   f. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
7. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
8. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
9. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
10. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
11. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
12. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.
13. Device Location-Indicating Lights: Locate in public space near the device they monitor.
14. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
15. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.
16. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist 100-mph (160-km/h), **as directed**, wind load with a gust factor of 1.3 without damage.

B. Connections
1. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.
   a. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
2. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
   a. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
   b. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
   c. Smoke dampers in air ducts of designated air-conditioning duct systems.
   d. Alarm-initiating connection to elevator recall system and components.
   e. Alarm-initiating connection to activate emergency lighting control.
   f. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.

g. Supervisory connections at valve supervisory switches.
h. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
i. Supervisory connections at elevator shunt trip breaker.
j. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
k. Supervisory connections at fire-pump engine control panel.

C. Identification
1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".
2. Install framed instructions in a location visible from fire-alarm control unit.

D. Grounding
1. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

E. Field Quality Control
1. Field tests shall be witnessed by authorities having jurisdiction.
2. Tests and Inspections:
a. Visual Inspection: Conduct visual inspection prior to testing.
1) Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
2) Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
b. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
c. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
d. Test audible appliances for the private operating mode according to manufacturer's written instructions.
e. Test visible appliances for the public operating mode according to manufacturer's written instructions.
f. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
4. Fire-alarm system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.
6. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
7. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 13852

SECTION 13852a - ZONED (DC LOOP) FIRE-ALARM SYSTEM

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for zoned (DC loop) fire alarm system. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fire-alarm control unit.
b. Manual fire-alarm boxes.
c. System smoke detectors.
d. Nonsystem smoke detectors.
e. Heat detectors.
f. Notification appliances.
g. Magnetic door holders.
h. Remote annunciator.
i. Digital alarm communicator transmitter.
j. Radio alarm transmitter.

C. Definitions
1. LED: Light-emitting diode.
2. NICET: National Institute for Certification in Engineering Technologies.

D. System Description
1. Noncoded system, dedicated to fire-alarm service only.

E. Submittals
1. General Submittal Requirements:
a. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Owner.
b. Shop Drawings shall be prepared by persons with the following qualifications:
1) Trained and certified by manufacturer in fire-alarm system design.
2) NICET-certified fire-alarm technician, Level III **OR** Level IV, **as directed**, minimum.
3) Licensed or certified by authorities having jurisdiction.
2. Product Data: For each type of product indicated.
3. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
a. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
b. Include voltage drop calculations for notification appliance circuits.
c. Include battery size calculations.
d. Include performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
e. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.

f. Include floor plans to indicate final outlet locations showing zone designation of each device. Show size and route of cable and conduits.

4. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Drawings showing the location of each smoke and heat detector, the ratings of each, and installation details as needed to comply with the listing conditions of the detector.
   b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
5. Qualification Data: For qualified Installer.
6. Field quality-control reports.
7. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. Deliver copies to authorities having jurisdiction, **as directed**, and include the following:
   a. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
   b. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
   c. Record copy of site-specific software.
   d. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
      1) Frequency of testing of installed components.
      2) Frequency of inspection of installed components.
      3) Requirements and recommendations related to results of maintenance.
      4) Manufacturer's user training manuals.
   e. Manufacturer's required maintenance related to system warranty requirements.
   f. Abbreviated operating instructions for mounting at fire-alarm control unit.
   g. Copy of NFPA 25.

F. Quality Assurance
1. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
2. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II **OR** Level III **OR** Level IV, **as directed**, technician.
3. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Project Conditions
1. Interruption of Existing Fire-alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-alarm service.
   b. Do not proceed with interruption of fire-alarm service without the Owner 's written permission.

H. Sequencing And Scheduling
1. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

2. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.2 PRODUCTS

A. Systems Operational Description
1. Fire-alarm signal initiation shall be by one or more of the following devices and systems, **as directed**:
   a. Manual stations.
   b. Heat detectors.
   c. Smoke detectors.
   d. Duct smoke detectors.
   e. Automatic sprinkler system water flow.
   f. Fire-extinguishing system operation.
   g. Fire standpipe system.
2. Fire-alarm signal shall initiate the following actions:
   a. Continuously operate alarm notification appliances.
   b. Identify alarm zone at fire-alarm control unit and remote annunciators, **as directed**.
   c. Transmit an alarm signal to the remote alarm receiving station.
3. Supervisory signal initiation shall be by one or more of the following devices and systems:
   a. Valve supervisory switch.
4. System trouble signal initiation shall be by one or more of the following devices and actions:
   a. Open circuits, shorts, and grounds in designated circuits.
   b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
   c. Loss of primary power at fire-alarm control unit.
   d. Ground or a single break in fire-alarm control unit internal circuits.
   e. Abnormal ac voltage at fire-alarm control unit.
   f. Break in standby battery circuitry.
   g. Failure of battery charging.
   h. Abnormal position of any switch at fire-alarm control unit or annunciator, **as directed**.
5. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators, **as directed**.

B. Fire-Alarm Control Unit
1. General Requirements for Fire-Alarm Control Unit:
   a. Modular, power-limited design with electronic modules, UL 864 listed.
      1) Include a real-time clock for time annotation of events.
2. Alphanumeric Display and System Controls: Display alarm, supervisory, and component status messages and the programming and control menu.
   a. Annunciator and Display: Liquid-crystal type, one line of 40 **OR** 80, **as directed**, characters, minimum.
3. Circuits:
   a. No Fewer Than Five Initiating Device Circuits:
      1) Four circuits, NFPA 72, Class B.
      2) One circuit(s), NFPA 72, Class A, Style 6
   b. No Fewer Than Two Notification Appliance Circuits: NFPA 72, Class B, Style Y.
4. Notification Appliance Circuit: Operation shall sound in a <**Insert pattern**>.
5. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be **OR** not be, **as directed**, connected to fire-alarm system.
6. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
7. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals **OR**

supervisory and digital alarm communicator transmitters **OR** digital alarm radio transmitters, **as directed**, shall be powered by the 24-V dc source.

a. Alarm current draw of the entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

8. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

a. Batteries: Sealed lead calcium **OR** Sealed, valve-regulated, recombinant lead acid **OR** Vented, wet-cell pocket, plate nickel cadmium, **as directed**.

9. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

C. Manual Fire-Alarm Boxes

1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

a. Single-action mechanism, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type.

b. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type.

c. Station Reset: Key- or wrench-operated switch.

d. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

e. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

D. System Smoke Detectors

1. General Requirements for System Smoke Detectors:

a. Operating at 24-V dc, nominal.

b. Detectors shall be four **OR** two, **as directed**,-wire type.

c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

d. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

e. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.

f. Provide multiple levels of detection sensitivity for each sensor, with alarm-verification feature, **as directed**.

2. Photoelectric Smoke Detectors: Comply with UL 268.

3. Ionization Smoke Detector: Comply with UL 268.

4. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

a. Remote indication and test, **as directed**, station. Operating key switch initiates an alarm test, **as directed**.

b. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.

c. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

d. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

E. Nonsystem Smoke Detectors

1. Single-Station Smoke Detectors:

a. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device, **as directed**.
b. Auxiliary Relays: One Form C rated at 0.5 A **OR** Form A and one Form C, both rated at 0.5 A, **as directed**.
c. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
d. Visible Notification Appliance: 177-cd strobe.
e. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise and fixed temperature, **as directed**.
f. Test Switch: Push-to-test; simulates smoke at rated obscuration.
g. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
h. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
i. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
j. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.

2. Single-Station Duct Smoke Detectors:
   a. Comply with UL 268A; operating at 120-V ac.
   b. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
      1) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
   c. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
   d. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

F. Heat Detectors
1. General Requirements for Heat Detectors: Comply with UL 521.
2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
   a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
3. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).
   a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.

G. Notification Appliances
1. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
   a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
2. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
3. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

4. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
   a. Rated Light Output:
      1) Indicated on Drawings.
      2) 15 **OR** 30 **OR** 75 **OR** 110 **OR** 177, **as directed**, cd.
         OR
         15/30/75/110 cd, selectable in the field.
   b. Mounting: Indicated on Drawings **OR** Wall mounted, **as directed**.
   c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
   d. Flashing shall be in a temporal pattern, synchronized with other units.
   e. Strobe Leads: Factory connected to screw terminals.
   f. Mounting Faceplate: Factory finished, red **OR** white, **as directed**.

H. Magnetic Door Holders
1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
   a. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
   b. Wall-Mounted Units: Flush mounted unless otherwise indicated.
   c. Rating: 24-V ac or dc.
   d. Rating: 120-V ac.
2. Material and Finish: Match door hardware.

I. Remote Annunciator
1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
   a. Mounting: Flush **OR** Surface, **as directed**, cabinet, NEMA 250, Type 1.
2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

J. Digital Alarm Communicator Transmitter
1. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
2. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one **OR** two, **as directed**, telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either, **as directed**, line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
3. Local functions and display at the digital alarm communicator transmitter shall include the following:
   a. Verification that both telephone lines are available.
   b. Programming device.
   c. LED display.
   d. Manual test report function and manual transmission clear indication.
   e. Communications failure with the central station or fire-alarm control unit.
4. Digital data transmission shall include the following:
   a. Zone of the alarm initiating device.
   b. Zone of the supervisory signal.
   c. Zone of the trouble initiating device.

d. Loss of ac supply or loss of power.
e. Low battery.
f. Abnormal test signal.
g. Communication bus failure.

5. Secondary Power: Integral rechargeable battery and automatic charger.
6. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

K. Radio Alarm Transmitter

1. Transmitter shall comply with NFPA 1221 and shall be listed and labeled by an NRTL.
2. Comply with 47 CFR 90.
3. Description: Manufacturer's standard commercial product; factory assembled, wired, tested, and ready for installation and operation.
   a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
   b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
   c. Normal Power Input: 120-V ac.
   d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
   e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph (160 km/h) with a gust factor of 1.3 without failure.
   f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
   g. Antenna-Cable Connectors: Weatherproof.
   h. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
4. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:
   a. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
   b. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
   c. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
   d. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
   e. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
   f. Local Fire-Alarm-System Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm, **as directed**.

L. Device Guards

1. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
   a. Factory fabricated and furnished by manufacturer of the device.
   b. Finish: Paint of color to match the protected device.

1.3 EXECUTION

A. Equipment Installation
1. Comply with NFPA 72 for installation of fire-alarm equipment.
2. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
   a. Connect new equipment to the existing control panel in the existing part of the building.
   b. Connect new equipment to the existing monitoring equipment at the supervising station.
   c. Expand, modify, and supplement the existing control **OR** monitoring, **as directed**, equipment as necessary to extend the existing control **OR** monitoring, **as directed**, functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
3. Smoke- or Heat-Detector Spacing:
   a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
   b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
   c. Smooth ceiling spacing shall not exceed 30 feet (9 m), **as directed**.
   d. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B, **as directed**, in NFPA 72.
   e. HVAC: Locate detectors not closer than 3 feet (1 m) **OR** 5 feet (1.5 m), **as directed**, from air-supply diffuser or return-air opening.
   f. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
4. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
5. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
6. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
7. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
8. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
9. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.
10. Device Location-Indicating Lights: Locate in public space near the device they monitor.
11. Fire-Alarm Control Unit: Surface mounting, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
12. Annunciator: Install with top of panel not more than 72 inches (1830 mm) above the finished floor.
13. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist 100-mph (160-km/h), **as directed**, wind load with a gust factor of 1.3 without damage.

B. Connections
1. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.
   a. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

2. Connect supervised interface devices to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled.
   a. Smoke dampers in air ducts of designated air-conditioning duct systems.
   b. Supervisory connections at valve supervisory switches.
   c. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
   d. Supervisory connections at fire-pump engine control panel.

C. Identification
1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".
2. Install framed instructions in a location visible from fire-alarm control unit.

D. Grounding
1. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

E. Field Quality Control
1. Field tests shall be witnessed by authorities having jurisdiction.
2. Tests and Inspections:
   a. Visual Inspection: Conduct the visual inspection prior to testing.
      1) Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
      2) Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
   b. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing, and Maintenance" Chapter in NFPA 72.
   c. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
   d. Test visible appliances for the public operating mode according to manufacturer's written instructions.
   e. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
3. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
4. Fire-alarm system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.
6. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
7. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with the visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 13852a

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SECTION 13920 - ELECTRIC-DRIVE, CENTRIFUGAL FIRE PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for electric-drive, centrifugal fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. End-suction, In-line, and Split-case fire pumps.
b. Fire-pump accessories and specialties.
c. Flowmeter systems.

C. Performance Requirements
1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS

A. General Requirements For Centrifugal Fire Pumps

1. Description: Factory-assembled and -tested fire-pump and driver unit.
2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

B. End-Suction Fire Pumps
1. Pump:
   a. Standard: UL 448, for end-suction pumps for fire service.
   b. Casing: Radially split case, cast iron with ASME B16.1 pipe-flange connections.
   c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
   d. Wear Rings: Replaceable bronze.
   e. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
   f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
3. Driver:
   a. Standard: UL 1004A.
   b. Type: Electric motor; NEMA MG 1, polyphase Design B.

C. In-Line Fire Pumps
1. Pump:
   a. Standard: UL 448, for in-line pumps for fire service.
   b. Casing: Radially split case, cast iron with ASME B16.1 pipe-flange connections.
   c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
   d. Wear Rings: Replaceable bronze.
   e. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
   f. Mounting: Pump and driver shaft is vertical, with motor above pump and pump on base.
2. Coupling: None or rigid.
3. Driver:
   a. Standard: UL 1004A.
   b. Type: Electric motor; NEMA MG 1, polyphase Design B.

D. Horizontally Mounted, Single-Stage, Split-Case Fire Pumps
1. Pump:
   a. Standard: UL 448, for split-case pumps for fire service.
   b. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
   c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
   d. Wear Rings: Replaceable bronze.
   e. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
   f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
3. Driver:
   a. Standard: UL 1004A.
   b. Type: Electric motor; NEMA MG 1, polyphase Design B.

E. Horizontally Mounted, Multistage, Split-Case Fire Pumps
   1. Pump:
      a. Standard: UL 448, for split-case pumps for fire service.
      b. Number of Stages: Two.
      c. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
      d. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
      e. Wear Rings: Replaceable bronze.
      f. Shaft and Sleeve: Steel shaft with bronze sleeve.
         1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
         2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
      g. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
   2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
   3. Driver:
      a. Standard: UL 1004A.
      b. Type: Electric motor; NEMA MG 1, polyphase Design B.

F. Vertically Mounted, Single-Stage, Split-Case Fire Pumps
   1. Pump:
      a. Standard: UL 448, for split-case pumps for fire service.
      b. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
      c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
      d. Wear Rings: Replaceable bronze.
      e. Shaft and Sleeve: Steel shaft with bronze sleeve.
         1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
         2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
      f. Mounting: Pump and driver shafts are vertical, with motor above pump and pump on base.
   2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
   3. Driver:
      a. Standard: UL 1004A.
      b. Type: Electric motor; NEMA MG 1, polyphase Design B.

G. Fire-Pump Accessories And Specialties
   1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
   2. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
   3. Relief Valves:
      a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
   4. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
   5. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
   6. Discharge Cone: Closed **OR** Open, **as directed**, type.
   7. Hose Valve Manifold Assembly:
      a. Standard: Comply with requirements in NFPA 20.
      b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
      c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
      d. Automatic Drain Valve: UL 1726.
      e. Manifold:
         1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
         2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.

3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
5) Escutcheon Plate: Brass or bronze; rectangular.
6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, chrome plated, **as directed**.
8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

OR

Manifold:

1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
3) Escutcheon Plate: Brass or bronze; round.
4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, chrome plated, **as directed**.
6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

H. Flowmeter Systems
1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
   a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

   OR

   Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

I. Grout
1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

J. Source Quality Control
1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
   a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
6. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
8. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
9. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
10. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Alignment
1. Align end-suction and split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
3. Align piping connections.
4. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

C. Connections
1. Comply with requirements for piping and valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to pumps and equipment to allow service and maintenance.
3. Connect relief-valve discharge to drainage piping or point of discharge.
4. Connect flowmeter-system meters, sensors, and valves to tubing.
5. Connect fire pumps to their controllers.

D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

E. Field Quality Control
1. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 13 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".

2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
3. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
   a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
   b. Test according to NFPA 20 for acceptance and performance testing.
   c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
6. Prepare test and inspection reports.
7. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

F. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 13920

SECTION 13920a - DIESEL-DRIVE, CENTRIFUGAL FIRE PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for diesel-drive, centrifugal fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. End-suction and Split-case fire pumps.
b. Fire-pump accessories and specialties.
c. Flowmeter systems.

C. Performance Requirements
1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, engine drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS

A. General Requirements For Centrifugal Fire Pumps
   1. Description: Factory-assembled and -tested fire-pump and driver unit.
   2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
   3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

B. End-Suction Fire Pumps
   1. Pump:
      a. Standard: UL 448, for end-suction pumps for fire service.
      b. Casing: Radially split case, cast iron with ASME B16.1 pipe-flange connections.
      c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
      d. Wear Rings: Replaceable bronze.
      e. Shaft and Sleeve: Steel shaft with bronze sleeve.
         1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
         2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
      f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
   2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
   3. Driver:
      a. Standard: UL 1247.
      b. Type: Diesel engine.
      c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
      d. Engine Cooling System: Factory-installed radiator.
         1) Coolant: Type recommended by driver manufacturer.

         OR

         Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
         1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
      e. Engine-Jacket Water Heater: Factory-installed electric elements.
      f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
      g. Fuel System: Comply with NFPA 20.
         1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.
      h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
         1) Exhaust Connector: Flexible type.
         2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.

C. Single-Stage, Split-Case Fire Pumps
   1. Pump:
      a. Standard: UL 448, for split-case pumps for fire service.
      b. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
      c. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
      d. Wear Rings: Replaceable bronze.
      e. Shaft and Sleeve: Steel shaft with bronze sleeve.
         1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
         2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
      f. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.

2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
3. Driver:
   a. Standard: UL 1247.
   b. Type: Diesel engine.
   c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
   d. Engine Cooling System: Factory-installed radiator.
      1) Coolant: Type recommended by driver manufacturer.

      OR

      Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
      1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
   e. Engine-Jacket Water Heater: Factory-installed electric elements.
   f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
   g. Fuel System: Comply with NFPA 20.
      1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.
   h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
      1) Exhaust Connector: Flexible type.
      2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.

D. Multistage, Split-Case Fire Pumps
1. Pump:
   a. Standard: UL 448, for split-case pumps for fire service.
   b. Number Stages: Two.
   c. Casing: Axially split case, cast iron with ASME B16.1 pipe-flange connections.
   d. Impeller: Cast bronze, statically and dynamically balanced, and keyed to shaft.
   e. Wear Rings: Replaceable bronze.
   f. Shaft and Sleeve: Steel shaft with bronze sleeve.
      1) Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
      2) Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
   g. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
2. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
3. Driver:
   a. Standard: UL 1247.
   b. Type: Diesel engine.
   c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
   d. Engine Cooling System: Factory-installed radiator.
      1) Coolant: Type recommended by driver manufacturer.

      OR

      Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
      1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
   e. Engine-Jacket Water Heater: Factory-installed electric elements.
   f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.

g. Fuel System: Comply with NFPA 20.
   1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.

h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
   1) Exhaust Connector: Flexible type.
   2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.

E. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
2. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
3. Relief Valves:
   a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
4. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
5. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
6. Discharge Cone: Closed **OR** Open, **as directed**, type.
7. Hose Valve Manifold Assembly:
   a. Standard: Comply with requirements in NFPA 20.
   b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
   c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
   d. Automatic Drain Valve: UL 1726.
   e. Manifold:
      1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
      2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
      3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
      4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      5) Escutcheon Plate: Brass or bronze; rectangular.
      6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
      8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

      OR

      Manifold:
      1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
      2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
      3) Escutcheon Plate: Brass or bronze; round.
      4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
      5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
      6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

F. Flowmeter Systems
1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.

2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
   a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

   OR

   Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

G. Grout
1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

H. Source Quality Control
1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
   a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation
1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
6. Install pressure gages on fire-pump suction and discharge flange pressure-gage tappings. Comply with requirements for pressure gages specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
8. Install fuel system according to NFPA 20.
9. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
10. Install exhaust-system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.

11. Install condensate-drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
12. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
13. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
14. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Alignment
1. Align end-suction and split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
3. Align piping connections.
4. Align pump and driver shafts for angular and parallel alignment according to HI 1.4 and to tolerances specified by manufacturer.

C. Connections
1. Comply with requirements for piping and valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to pumps and equipment to allow service and maintenance.
3. Connect relief-valve discharge to drainage piping or point of discharge.
4. Connect flowmeter-system meters, sensors, and valves to tubing.
5. Connect fire pumps to their controllers.

D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

E. Field Quality Control
1. Test each fire pump with its controller as a unit. Comply with requirements for diesel-engine-driver fire-pump controllers specified in Division 13 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".
2. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
   a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
   b. Test according to NFPA 20 for acceptance and performance testing.
   c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

F. Startup Service
1. Perform startup service.
a. Complete installation and startup checks according to manufacturer's written instructions.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 13920a

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SECTION 13920b - ELECTRIC-DRIVE, VERTICAL-TURBINE FIRE PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for electric-drive, vertical-turbine fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
   a. Vertical-turbine fire pumps.
   b. Fire-pump accessories and specialties.
   c. Flowmeter systems.

C. Performance Requirements
1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS

A. General Requirements For Vertical-Turbine Fire Pumps
   1. Description: Factory-assembled and -tested fire-pump and driver unit.
   2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
   3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

B. Vertical-Turbine Fire Pumps
   1. Pump Head: Cast iron, for surface discharge.
      a. Discharge Outlet: With flange according to ASME B16.1 except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
      b. Pump Head Seal: Stuffing box and packing.
      c. Base: Cast iron or steel with hole for electrical cable.
   2. Pump:
      a. Standard: UL 448, for vertical-turbine pumps for fire service.
      b. Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
      c. Line Shaft Bearings: Rubber sleeve, water lubricated.
      d. Line Shaft: Steel.
      e. Line Shaft Bearings: Corrosion resistant, oil lubricated.
      f. Impeller Shaft: Monel metal or stainless steel.
      g. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
      h. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less.
      i. Suction Strainer: Cast or fabricated, bronze or stainless steel, and sized to restrict passage of 0.5-inch (12.7-mm) spheres.
   3. Driver:
      a. Standard: UL 1004A.
      b. Type: Electric motor; NEMA MG 1, polyphase Design B.
      c. Mounting: On pump head above pump.

C. Fire-Pump Accessories And Specialties
   1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
   2. Relief Valves:
      a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
   3. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
   4. Discharge Cone: Closed **OR** Open, **as directed**, type.
   5. Hose Valve Manifold Assembly:
      a. Standard: Comply with requirements in NFPA 20.
      b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
      c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
      d. Automatic Drain Valve: UL 1726.
      e. Manifold:
         1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
         2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
         3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
         4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
         5) Escutcheon Plate: Brass or bronze; rectangular.
         6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.

7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

OR

Manifold:

1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
3) Escutcheon Plate: Brass or bronze; round.
4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

D. Flowmeter Systems

1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
   a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

   OR

   Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

E. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. Source Quality Control

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Protection Tests."
   a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to supported equipment.

3. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
6. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
7. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
8. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
9. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Alignment

1. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
3. Align piping connection.
4. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.

C. Connections

1. Comply with requirements for piping and valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to pumps and equipment to allow service and maintenance.
3. Connect relief-valve discharge to drainage piping or point of discharge.
4. Connect flowmeter-system meters, sensors, and valves to tubing.
5. Connect fire pumps to their controllers.

D. Identification

1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

E. Field Quality Control

1. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 13 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps"
2. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
   a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
   b. Test according to NFPA 20 for acceptance and performance testing.

c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.
6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

F. Startup Service
1. Perform startup service.
a. Complete installation and startup checks according to manufacturer's written instructions.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 13920b

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SECTION 13920c - DIESEL-DRIVE, VERTICAL-TURBINE FIRE PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for diesel-drive, vertical-turbine fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
   a. Vertical-turbine fire pumps.
   b. Fire-pump accessories and specialties.
   c. Flowmeter systems.

C. Performance Requirements
1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, right-angle gear drives, engine drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

1.2 PRODUCTS

A. General Requirements For Vertical-Turbine Fire Pumps
1. Description: Factory-assembled and -tested fire pump, right-angle gear drive, and driver.
2. Base: Fabricated and attached to fire pump, right-angle gear drive, and driver with reinforcement to resist movement of pump, gear drive, and driver during seismic events when base is anchored to building substrate.
3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

B. Vertical-Turbine Fire Pumps
1. Pump Head: Cast iron, for surface discharge.
   a. Discharge Outlet: With flange according to ASME B16.1 except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
   b. Pump Head Seal: Stuffing box and packing.
   c. Base: Cast iron or steel with hole for electrical cable.
2. Pump:
   a. Standard: UL 448, for vertical-turbine pumps for fire service.
   b. For static water levels of 50 feet (15 m) or less and for water-lubricated bearings.
      1) Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
      2) Line Shaft Bearings: Rubber sleeve, water lubricated.
   c. For static water levels between 50 and 200 feet (15 and 61 m) and for oil-lubricated bearings.
      1) Line Shaft: Steel.
      2) Line Shaft Bearings: Corrosion resistant, oil lubricated.
   d. Impeller Shaft: Monel metal or stainless steel.
   e. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
   f. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less.
   g. Suction Strainer: Cast or fabricated, bronze or stainless steel, and sized to restrict passage of 0.5-inch (12.7-mm) spheres.
3. Right-Angle Gear Drive:
   a. Description: FM-Approved, speed-reduction gear drive for pump speed control. Provide ratio for outlet speed of approximately 1760 rpm.
4. Engine-to-Gear Drive Shaft: FM-Approved, telescoping, steel drive shaft with universal joint and grease fitting at each end. Include metal shaft guard.
5. Driver:
   a. Standard: UL 1247.
   b. Type: Diesel engine.
   c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
   d. Engine Cooling System: Factory-installed radiator.
      1) Coolant: Type recommended by driver manufacturer.

      OR

      Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
      1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
   e. Engine-Jacket Water Heater: Factory-installed electric elements.
   f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
   g. Fuel System: According to NFPA 20.
      1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.

h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
   1) Exhaust Connector: Flexible type.
   2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.

C. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
2. Relief Valves:
   a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
3. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
4. Discharge Cone: Closed **OR** Open, **as directed**, type.
5. Hose Valve Manifold Assembly:
   a. Standard: Comply with requirements in NFPA 20.
   b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
   c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
   d. Automatic Drain Valve: UL 1726.
   e. Manifold:
      1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
      2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
      3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
      4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      5) Escutcheon Plate: Brass or bronze; rectangular.
      6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
      8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

      OR

      Manifold:
      1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
      2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
      3) Escutcheon Plate: Brass or bronze; round.
      4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
      5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
      6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

D. Flowmeter Systems
1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
2. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 250 psig (1725 kPa), **as directed**.
3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter. Include bracket or device for wall mounting.
   a. Tubing Package: NPS 1/8 or NPS 1/4 (DN 6 or DN 10) soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

OR
Portable Flowmeter: Compatible with flow sensor; with dial not less than 4-1/2 inches (115 mm) in diameter and with two 12-foot- (3.7-m-) long hoses in carrying case.

E. Grout
1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

F. Source Quality Control
1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
   a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation
1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
6. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**.
7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
8. Install fuel system according to NFPA 20.
9. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
10. Install exhaust system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.
11. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
12. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
13. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

14. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

B. Alignment
1. Align fire-pump-driver, right-angle gear-drive, and fire-pump shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
3. Align piping connections.
4. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.

C. Connections
1. Comply with requirements for piping and valves specified in Division 13 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Fire-suppression Sprinklers", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to pumps and equipment to allow service and maintenance.
3. Connect relief-valve discharge to drainage piping or point of discharge.
4. Connect flowmeter-system meters, sensors, and valves to tubing.
5. Connect fire pumps to their controllers.

D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

E. Field Quality Control
1. Test each fire pump with its right-angle gear drive and controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 13 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".
2. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
   a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
   b. Test according to NFPA 20 for acceptance and performance testing.
   c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.
6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

F. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.

G. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain fire pumps, right-angle gear drives, and fire-pump controllers.

END OF SECTION 13920c

SECTION 13920d - PRESSURE-MAINTENANCE PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for pressure-maintenance pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Multistage, pressure-maintenance pumps.
b. Regenerative-turbine, pressure-maintenance pumps.
c. Submersible, pressure-maintenance pumps.
d. Vertical-turbine, pressure-maintenance pumps.

C. Performance Requirements
1. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig (1200 kPa) minimum unless higher pressure rating is indicated.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For pumps, accessories, and specialties. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Field quality-control reports.
4. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.2 PRODUCTS

A. Multistage, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, multistage, barrel-type vertical pump as defined in HI 2.1-2.2 and HI 2.3; designed for surface installation with pump and motor direct coupled and mounted vertically.
2. Pump Construction:
a. Barrel: Stainless steel.
b. Suction and Discharge Chamber: Cast iron with flanged inlet and outlet.
c. Pump Head/Motor Mount: Cast iron.
d. Impellers: Stainless steel, balanced, and keyed to shaft.
e. Pump Shaft: Stainless steel.
f. Seal: Mechanical type with carbon rotating face and silicon-carbide stationary seat.
g. Intermediate Chamber Bearings: Aluminum-oxide ceramic or bronze.
h. Chamber-Base Bearing: Tungsten carbide.
i. O-Rings: EPDM or NBR.

3. Motor: Single speed with permanently lubricated ball bearings and rigidly mounted to pump head. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
   a. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.
4. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

B. Regenerative-Turbine, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, close-coupled, single-stage, regenerative-turbine centrifugal pump as defined in HI 1.1-1.2 and HI 1.3; with pump and motor mounted horizontally.
2. Pump Construction:
   a. Casing: Radially split, cast iron, with threaded inlet and outlet.
   b. Impeller: Bronze, balanced, and keyed to shaft.
   c. Pump Shaft: Stainless steel **OR** steel, **as directed**, with deflector.
   d. Shaft Sleeve: Bronze.
   e. Seal: Mechanical type with spring-loaded rotating head.
3. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
   a. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.
4. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

C. Submersible, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, vertical, multistage, submersible pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted below pump.
2. Pump Construction:
   a. Pump Head or Elbow: Cast iron, for surface discharge, with flanged or threaded connections.
   b. Pump Shaft: Stainless steel.
   c. Bearings: Bronze.
   d. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
   e. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less, with strainer of cast or fabricated bronze or stainless steel between pump and bowl section.
3. Motor: Single speed with permanently lubricated ball bearings and capable of continuous operation under water. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."
   a. Power Cord: Capable of continuous under-water operation, factory-connected to motor for field connection to controller, and at least 10 feet (3 m) long.
4. Base: Cast iron or steel with hole for electrical cable.
5. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

D. Vertical-Turbine, Pressure-Maintenance Pumps
1. Description: Factory-assembled and -tested, vertical, multistage, open-line-shaft turbine pump as defined in HI 2.1-2.2 and HI 2.3; with pump motor mounted above pump head.
2. Pump Construction:
   a. Pump Head: Cast iron, for surface discharge, with flange except connections may be threaded in sizes in which flanges are not available.
   b. Pump Head Seal: Stuffing box and stuffing.
   c. For static water levels of 50 feet (15 m) or less and for water-lubricated bearings.
      1) Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
      2) Line Shaft Bearings: Rubber sleeve, water lubricated.
   d. For static water levels between 50 and 200 feet (15 and 61 m) and for oil-lubricated bearings.
      1) Line Shaft: Steel.

2) Line Shaft Bearings: Corrosion resistant, oil lubricated.

e. Impeller Shaft: Monel metal or stainless steel.

f. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.

g. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less, with strainer of cast or fabricated bronze or stainless steel at bottom.

3. Motor: Single speed with permanently lubricated ball bearings. Comply with requirements in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."

a. Power Cord: Factory-connected to motor for field connection to controller and at least 10 feet (3 m) long.

4. Base: Cast iron or steel with hole for electrical cable.

5. Nameplate: Permanently attached to pump and indicating capacity and characteristics.

E. Motors

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for Fire Suppression Equipment."

a. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

b. Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 16 Sections.

1.3 EXECUTION

A. Equipment Installation

1. NFPA Standard: Comply with NFPA 20 for installation of pressure-maintenance pumps.

2. Base-Mounted Pump Mounting: Install pumps on concrete bases. Comply with requirements for concrete bases specified in Division 3 Section "Cast-in-Place Concrete."

a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

d. Install anchor bolts to elevations required for proper attachment to supported equipment.

e. Attach pumps to equipment base using anchor bolts.

3. Install multistage and regenerative-turbine, pressure-maintenance pumps according to HI 1.4.

4. Install submersible and vertical-turbine, pressure-maintenance pumps according to HI 2.4.

B. Field Quality Control

1. Perform tests and inspections.

a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Tests and Inspections:

a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Pressure-maintenance pumps will be considered defective if they do not pass tests and inspections.

4. Prepare test and inspection reports.

C. Adjusting

1. Lubricate pumps as recommended by manufacturer.

2. Set field-adjustable pressure-switch ranges as indicated.

END OF SECTION 13920d

SECTION 13930 - WET-PIPE FIRE-SUPPRESSION SPRINKLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for wet-pipe fire-suppression sprinklers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Pipes, fittings, and specialties.
b. Fire-protection valves.
c. Fire-department connections.
d. Sprinklers.
e. Excess-pressure pumps.
f. Alarm devices.
g. Manual control stations.
h. Control panels.
i. Pressure gages.

C. Definitions
1. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig (1200 kPa), but not higher than 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
2. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig (1200 kPa) maximum.

D. System Descriptions
1. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.
2. Deluge Sprinkler System: Open sprinklers are attached to piping connected to water supply through deluge valve. Fire-detection system, in same area as sprinklers, opens valve. Water flows into piping system and discharges from attached sprinklers when valve opens.

E. Performance Requirements
1. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
2. High-Pressure Piping System Component: Listed for 250-psig (1725-kPa) minimum **OR** 300-psig (2070-kPa), **as directed**, working pressure.
3. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
4. Sprinkler system design shall be approved by authorities having jurisdiction.
a. Margin of Safety for Available Water Flow and Pressure: 10 **OR** 20, **as directed**, percent, including losses through water-service piping, valves, and backflow preventers.
b. Sprinkler Occupancy Hazard Classifications:
1) Automobile Parking Areas: Ordinary Hazard, Group 1.
2) Building Service Areas: Ordinary Hazard, Group 1.
3) Churches: Light Hazard.
4) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
5) Dry Cleaners: Ordinary Hazard, Group 2.

6) General Storage Areas: Ordinary Hazard, Group 1.
7) Laundries: Ordinary Hazard, Group 1.
8) Libraries except Stack Areas: Light Hazard.
9) Library Stack Areas: Ordinary Hazard, Group 2.
10) Machine Shops: Ordinary Hazard, Group 2.
11) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
12) Office and Public Areas: Light Hazard.
13) Plastics Processing Areas: Extra Hazard, Group 2.
14) Printing Plants: Extra Hazard, Group 1.
15) Repair Garages: Ordinary Hazard, Group 2.
16) Residential Living Areas: Light Hazard.
17) Restaurant Service Areas: Ordinary Hazard, Group 1.
18) Solvent Cleaning Areas: Extra Hazard, Group 2.
19) Upholstering Plants: Extra Hazard, Group 1.

c. Minimum Density for Automatic-Sprinkler Piping Design:
1) Residential (Dwelling) Occupancy: 0.05 gpm over 400-sq. ft. (2.04 mm/min. over 37.2-sq. m) area.
2) Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
3) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
4) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.
5) Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. (12.2 mm/min. over 232-sq. m) area.
6) Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. (16.3 mm/min. over 232-sq. m) area.
7) Special Occupancy Hazard: As determined by authorities having jurisdiction.

d. Minimum Density for Deluge-Sprinkler Piping Design:
1) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm (6.1 mm/min.) over entire area.
2) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm (8.1 mm/min.) over entire area.
3) Extra-Hazard, Group 1 Occupancy: 0.30 gpm (12.2 mm/min.) over entire area.
4) Extra-Hazard, Group 2 Occupancy: 0.40 gpm (16.3 mm/min.) over entire area.
5) Special Occupancy Hazard: As determined by authorities having jurisdiction.

e. Maximum Protection Area per Sprinkler: Per UL listing.
OR
Maximum Protection Area per Sprinkler:
1) Residential Areas: 400 sq. ft. (37 sq. m).
2) Office Spaces: 120 sq. ft. (11.1 sq. m) **OR** 225 sq. ft. (20.9 sq. m), **as directed**.
3) Storage Areas: 130 sq. ft. (12.1 sq. m).
4) Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
5) Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
6) Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

f. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
1) Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
2) Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.
3) Extra-Hazard Occupancies: 500 gpm (31.5 L/s) for 90 to 120 minutes.

5. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

F. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:

a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content and chemical components.

3. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Qualification Data: For qualified Installer and professional engineer, **as directed**.
6. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
7. Welding certificates.
8. Fire-hydrant flow test report.
9. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
10. Field quality-control reports.
11. Operation and maintenance data.

G. Quality Assurance
1. Installer Qualifications:
   a. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
      1) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
2. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
   a. NFPA 13, "Installation of Sprinkler Systems."
   b. NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height."
   c. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

H. Project Conditions
1. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of sprinkler service.
   b. Do not proceed with interruption of sprinkler service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials
1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Steel Pipe And Fittings
1. Standard Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

2. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
3. Thinwall Galvanized- and Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
5. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, thinwall, with plain ends and wall thickness less than Schedule 10.
6. Hybrid Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.
7. Schedule 5 Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, lightwall, with plain ends.
8. Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
9. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.
10. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
11. Malleable- or Ductile-Iron Unions: UL 860.
12. Cast-Iron Flanges: ASME 16.1, Class 125.
13. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
14. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
15. Grooved-Joint, Steel-Pipe Appurtenances:
    a. Pressure Rating: 175 psig (1200 kPa) **OR** 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**, minimum.
    b. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
    c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
16. Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

C. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.
2. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
3. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
6. Copper Pressure-Seal Fittings:
    a. Standard: UL 213.
    b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
    c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze fitting with EPDM-rubber O-ring seal in each end.
7. Grooved-Joint, Copper-Tube Appurtenances:
    a. Grooved-End, Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.

b. Grooved-End-Tube Couplings: To fit copper-tube dimensions, with design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.

8. Copper-Tube, Extruded-Tee Connections:
   a. Description: Tee formed in copper tube according to ASTM F 2014.

D. CPVC Pipe And Fittings
1. CPVC Pipe: ASTM F 442/F 442M and UL 1821, SDR 13.5, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), with plain ends. Include "LISTED" and "CPVC SPRINKLER PIPE" markings.
2. CPVC Fittings: UL listed or FM approved, for 175-psig (1200-kPa) rated pressure at 150 deg F (62 deg C), socket type. Include "LISTED" and "CPVC SPRINKLER FITTING" markings.
   a. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): ASTM F 438 and UL 1821, Schedule 40, socket type.
   b. NPS 2 to NPS 3 (DN 50 to DN 80): ASTM F 439 and UL 1821, Schedule 80, socket type.
   c. CPVC-to-Metal Transition Fittings: CPVC, one piece, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
   d. CPVC-to-Metal Transition Unions: CPVC, with dimensions equivalent to pipe; one end with threaded brass insert, and one socket end.
   e. Flanges: CPVC, one or two pieces.

E. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
   a. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
   b. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
4. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
5. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493, solvent cement recommended by pipe and fitting manufacturer, and made for joining CPVC sprinkler pipe and fittings. Include cleaner or primer recommended by pipe and fitting manufacturer.
   a. Use solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Use adhesive primer that has a VOC content of 650 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Plastic, Pipe-Flange Gasket, and Bolts and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

F. Cover System For Sprinkler Piping
1. Description: System of support brackets and covers made to protect sprinkler piping.
2. Brackets: Glass-reinforced nylon.
3. Covers: Extruded PVC sections of length, shape, and size required for size and routing of CPVC piping.

G. Listed Fire-Protection Valves
1. General Requirements:
   a. Valves shall be UL listed or FM approved.
   b. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
   c. Minimum Pressure Rating for High-Pressure Piping: 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
2. Ball Valves:

a. Standard: UL 1091 except with ball instead of disc.
b. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
c. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
d. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.

3. Bronze Butterfly Valves:
   a. Standard: UL 1091.
   b. Pressure Rating: 175 psig (1200 kPa).
   c. Body Material: Bronze.
   d. End Connections: Threaded.
4. Iron Butterfly Valves:
   a. Standard: UL 1091.
   b. Pressure Rating: 175 psig (1200 kPa).
   c. Body Material: Cast or ductile iron.
   d. Style: Lug or wafer.
      OR
      End Connections: Grooved.
5. Check Valves:
   a. Standard: UL 312.
   b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Type: Swing check.
   d. Body Material: Cast iron.
   e. End Connections: Flanged or grooved.
6. Bronze OS&Y Gate Valves:
   a. Standard: UL 262.
   b. Pressure Rating: 175 psig (1200 kPa).
   c. Body Material: Bronze.
   d. End Connections: Threaded.
7. Iron OS&Y Gate Valves:
   a. Standard: UL 262.
   b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Body Material: Cast or ductile iron.
   d. End Connections: Flanged or grooved.
8. Indicating-Type Butterfly Valves:
   a. Standard: UL 1091.
   b. Pressure Rating: 175 psig (1200 kPa) minimum.
   c. Valves NPS 2 (DN 50) and Smaller:
      1) Valve Type: Ball or butterfly.
      2) Body Material: Bronze.
      3) End Connections: Threaded.
   d. Valves NPS 2-1/2 (DN 65) and Larger:
      1) Valve Type: Butterfly.
      2) Body Material: Cast or ductile iron.
      3) End Connections: Flanged, grooved, or wafer.
   e. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch **OR** electrical, 115-V ac, prewired, two-circuit, supervisory switch **OR** visual, **as directed**, indicating device.
9. NRS Gate Valves:
   a. Standard: UL 262.
   b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Body Material: Cast iron with indicator post flange.
   d. Stem: Nonrising.
   e. End Connections: Flanged or grooved.
10. Indicator Posts:
    a. Standard: UL 789.

b. Type: Horizontal for wall mounting.
c. Body Material: Cast iron with extension rod and locking device.
d. Operation: Wrench **OR** Hand wheel, **as directed**.

H. Trim And Drain Valves
1. General Requirements:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating: 175 psig (1200 kPa) minimum.
2. Angle Valves.
3. Ball Valves.
4. Globe Valves.
5. Plug Valves.

I. Specialty Valves
1. General Requirements:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating:
1) Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
2) High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast or ductile iron.
d. Size: Same as connected piping.
e. End Connections: Flanged or grooved.
2. Alarm Valves:
a. Standard: UL 193.
b. Design: For horizontal or vertical installation.
c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, **as directed**, and fill-line attachment with strainer.
d. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
OR
Drip Cup Assembly: Pipe drain with check valve to main drain piping.
3. Deluge Valves:
a. Standard: UL 260.
b. Design: Hydraulically operated, differential-pressure type.
c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
d. Wet, Pilot-Line Trim Set: Include gage to read push-rod chamber pressure, globe valve for manual operation of deluge valve, and connection for actuation device.
4. Automatic (Ball Drip) Drain Valves:
a. Standard: UL 1726.
b. Pressure Rating: 175 psig (1200 kPa) minimum.
c. Type: Automatic draining, ball check.
d. Size: NPS 3/4 (DN 20).
e. End Connections: Threaded.

J. Fire-Department Connections
1. Exposed-Type, Fire-Department Connection:
a. Standard: UL 405.
b. Type: Exposed, projecting, for wall mounting.
c. Pressure Rating: 175 psig (1200 kPa) minimum.
d. Body Material: Corrosion-resistant metal.

e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
f. Caps: Brass, lugged type, with gasket and chain.
g. Escutcheon Plate: Round, brass, wall type.
h. Outlet: Back, with pipe threads.
i. Number of Inlets: Two **OR** Three, **as directed**.
j. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
k. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
l. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.

2. Flush-Type, Fire-Department Connection:
a. Standard: UL 405.
b. Type: Flush, for wall mounting.
c. Pressure Rating: 175 psig (1200 kPa) minimum.
d. Body Material: Corrosion-resistant metal.
e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
f. Caps: Brass, lugged type, with gasket and chain.
g. Escutcheon Plate: Rectangular, brass, wall type.
h. Outlet: With pipe threads.
i. Body Style: Horizontal **OR** Square **OR** Vertical, **as directed**.
j. Number of Inlets: Two **OR** Three **OR** Four **OR** Six, **as directed**.
k. Outlet Location: Back **OR** Bottom **OR** Left side **OR** Right side **OR** Top, **as directed**.
l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR "**AUTO SPKR", **as directed**.
m. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**.

3. Yard-Type, Fire-Department Connection:
a. Standard: UL 405.
b. Type: Exposed, freestanding.
c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
d. Body Material: Corrosion-resistant metal.
e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
f. Caps: Brass, lugged type, with gasket and chain.
g. Escutcheon Plate: Round, brass, floor type.
h. Outlet: Bottom, with pipe threads.
i. Number of Inlets: Two **OR** Three **OR** Four, **as directed**.
j. Sleeve: Brass **OR** Not required, **as directed**.
k. Sleeve Height: 18 inches (460 mm).
l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
m. Finish, Including Sleeve: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.

K. Sprinkler Specialty Pipe Fittings
1. Branch Outlet Fittings:
a. Standard: UL 213.

b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
d. Type: Mechanical-T and -cross fittings.
e. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
f. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
g. Branch Outlets: Grooved, plain-end pipe, or threaded.

2. Flow Detection and Test Assemblies:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
d. Size: Same as connected piping.
e. Inlet and Outlet: Threaded.

3. Branch Line Testers:
a. Standard: UL 199.
b. Pressure Rating: 175 psig (1200 kPa).
c. Body Material: Brass.
d. Size: Same as connected piping.
e. Inlet: Threaded.
f. Drain Outlet: Threaded and capped.
g. Branch Outlet: Threaded, for sprinkler.

4. Sprinkler Inspector's Test Fittings:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast- or ductile-iron housing with sight glass.
d. Size: Same as connected piping.
e. Inlet and Outlet: Threaded.

5. Adjustable Drop Nipples:
a. Standard: UL 1474.
b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Steel pipe with EPDM-rubber O-ring seals.
d. Size: Same as connected piping.
e. Length: Adjustable.
f. Inlet and Outlet: Threaded.

6. Flexible, Sprinkler Hose Fittings:
a. Standard: UL 1474.
b. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
d. Size: Same as connected piping, for sprinkler.

L. Sprinklers
1. General Requirements:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
c. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
d. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.

2. Automatic Sprinklers with Heat-Responsive Element:
a. Early-Suppression, Fast-Response Applications: UL 1767.
b. Nonresidential Applications: UL 199.
c. Residential Applications: UL 1626.

d. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

3. Open Sprinklers with Heat-Responsive Element Removed: UL 199.
   a. Characteristics:
      1) Nominal 1/2-inch (12.7-mm) Orifice: With Discharge Coefficient K between 5.3 and 5.8.
      2) Nominal 17/32-inch (13.5-mm) Orifice: With Discharge Coefficient K between 7.4 and 8.2.
4. Sprinkler Finishes:
   a. Chrome plated.
   b. Bronze.
   c. Painted.
5. Special Coatings:
   a. Wax.
   b. Lead.
   c. Corrosion-resistant paint.
6. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   a. Ceiling Mounting: Chrome-plated steel, one piece, flat **OR** Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment **OR** Plastic, white finish, one piece, flat, **as directed**.
   b. Sidewall Mounting: Chrome-plated steel **OR** Plastic, white finish, **as directed**, one piece, flat.
7. Sprinkler Guards:
   a. Standard: UL 199.
   b. Type: Wire cage with fastening device for attaching to sprinkler.

M. Excess-Pressure Pumps
1. Pump: Factory-fabricated, positive-displacement, gear type.
   a. Pump and Motor: Directly connected.
   b. Motor: Comply with requirements in Division 15 Section "Common Work Results For Fire Suppression".
2. Miscellaneous Components: Wet-pipe kit of switches, fittings, valves, mounting brackets, and connections for power, hydraulic piping, and wiring from alarm devices.
3. Motor Control: Differential-pressure switch.
4. Lights: To indicate sprinkler system's operating condition.
   a. White Light: Pressure is normal.
   b. Red Light: Pressure is low.
5. Capacity: 2.0 gpm at 75-psig (0.13 L/s at 520-kPa) differential pressure and 1/3 hp **OR** 1.85 gpm at 100-psig (0.12 L/s at 690-kPa) differential pressure and 1/2 hp **OR** 3.5 gpm at 100-psig (0.22 L/s at 690-kPa) differential pressure and 1/2 hp, **as directed**.

N. Alarm Devices
1. Alarm-device types shall match piping and equipment connections.
2. Water-Motor-Operated Alarm:
   a. Standard: UL 753.
   b. Type: Mechanically operated, with Pelton wheel.
   c. Alarm Gong: Cast aluminum with red-enamel factory finish.
   d. Size: 10-inch (250-mm) diameter.
   e. Components: Shaft length, bearings, and sleeve to suit wall construction.
   f. Inlet: NPS 3/4 (DN 20).
   g. Outlet: NPS 1 (DN 25) drain connection.
3. Electrically Operated Alarm Bell:

a. Standard: UL 464.
b. Type: Vibrating, metal alarm bell.
c. Size: 6-inch (150-mm) minimum-diameter **OR** 8-inch (200-mm) minimum-diameter **OR** 10-inch (250-mm) diameter, **as directed**.
d. Finish: Red-enamel factory finish, suitable for outdoor use.

4. Water-Flow Indicators:
   a. Standard: UL 346.
   b. Water-Flow Detector: Electrically supervised.
   c. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
   d. Type: Paddle operated.
   e. Pressure Rating: 250 psig (1725 kPa).
   f. Design Installation: Horizontal or vertical.
5. Pressure Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised water-flow switch with retard feature.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design Operation: Rising pressure signals water flow.
6. Valve Supervisory Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design: Signals that controlled valve is in other than fully open position.
7. Indicator-Post Supervisory Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design: Signals that controlled indicator-post valve is in other than fully open position.

O. Manual Control Stations
1. Description: UL listed or FM approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

P. Control Panels
1. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire-alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.
   a. Panels: UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
   b. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
      OR
      Manual Control Stations: Hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

Q. Pressure Gages

1. Standard: UL 393.
2. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
3. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum **OR** 0 to 300 psig (0 to 2070 kPa), **as directed**.
4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
5. Air System Piping Gage: Include retard feature, **directed**, and "AIR" or "AIR/WATER" label on dial face.

R. Escutcheons
1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
2. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated **OR** rough-brass, **as directed**, finish with set-screws.
3. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.
4. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw **OR** spring clips, **as directed**.
5. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated **OR** rough-brass, **as directed**, finish with concealed hinge and set-screw.
6. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, set-screw **OR** spring clips, **as directed**.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.
8. Split-Casting Floor Plates: Cast brass with concealed hinge.

S. Sleeves
1. Cast-Iron Wall Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set-screws.

T. Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

U. Grout
1. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink, and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Preparation
1. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
2. Report test results promptly and in writing.

B. Service-Entrance Piping
1. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Division 02 Section "Facility Fire-suppression Water-service Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements for backflow preventers in Division 02 Section "Facility Fire-suppression Water-service Piping", **as directed**.
OR
Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

C. Water-Supply Connections
1. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Division 15 Section "Domestic Water Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements for backflow preventers in Division 15 Section "Domestic Water Piping Specialties", **as directed**.
OR
Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. Piping Installation
1. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   a. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Owner before deviating from approved working plans.
2. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.
3. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.
4. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
5. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
6. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
7. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
8. Install sprinkler piping with drains for complete system drainage.
9. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
10. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
11. Install alarm devices in piping systems.
12. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
13. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

14. Pressurize and check preaction sprinkler system piping and air-pressure maintenance devices **OR** air compressors, **as directed**.
15. Fill sprinkler system piping with water.
16. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Division 15 Section "Heat Tracing For Fire-suppression Piping" and for piping insulation in Division 15 Section "Fire-suppression Systems Insulation".

E. Joint Construction
1. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
2. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
3. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
4. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
5. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
6. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
7. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
8. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
9. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
10. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
    a. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
11. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
12. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
13. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
14. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
15. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
16. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.
17. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
18. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

19. Plastic-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
    b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

F. Installation Of Cover System For Sprinkler Piping
1. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and with NFPA 13 or NFPA 13R for supports.

G. Valve And Specialties Installation
1. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
2. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
3. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
4. Specialty Valves:
    a. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
    b. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.
    c. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

H. Excess-Pressure Pump Installation
1. Assemble components and mount on wood backing. Comply with requirements in Division 06 Section "Rough Carpentry" for wood backing material and installation.
2. Install excess-pressure pumps, controls, devices, and supports for sprinkler piping application.
    a. Mounting: Install on wall, where indicated **OR** attached to water-supply pipe, **as directed**.

I. Sprinkler Installation
1. Install sprinklers in suspended ceilings in center of narrow dimension of, **as directed**, acoustical ceiling panels.
2. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
3. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

J. Fire-Department Connection Installation
1. Install wall-type, fire-department connections.
2. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-place Concrete".
    a. Install two **OR** three, **as directed**, protective pipe bollards around **OR** on sides of, **as directed**, each fire-department connection. Comply with requirements for bollards in Division 05 Section "Metal Fabrications".
3. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

K. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors.
2. Escutcheons for New Piping:
    a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
    b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set-screw **OR** stamped steel with set-screw or spring clips **OR** stamped steel with spring clips, **as directed**.

c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set-screw **OR** One piece or split plate, stamped steel with set-screw **OR** Split plate, stamped steel with set-screw, **as directed**.

d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.

e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.

f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3. Escutcheons for Existing Piping:

a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.

b. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.

d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set-screw, **as directed**.

e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set-screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set-screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set-screw or spring clips, **as directed**.

f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set-screw or spring clips, **as directed**.

g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

L. Sleeve Installation

1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
2. Sleeves are not required for core-drilled holes.
3. Permanent sleeves are not required for holes formed by removable PE sleeves.
4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
5. Install sleeves in new partitions, slabs, and walls as they are built.
6. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.
9. Seal space outside of sleeves in concrete slabs and walls with grout.
10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
11. Install sleeve materials according to the following applications:

a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.

b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe **OR** Stack sleeve fittings, **as directed**.

1) Extend sleeves 2 inches (50 mm) above finished floor level.
2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements for flashing in Division 07 Section "Sheet Metal Flashing And Trim".

c. Sleeves for Piping Passing through Gypsum-Board Partitions:
1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
3) Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.

e. Sleeves for Piping Passing through Exterior Concrete Walls:
1) Galvanized-steel-pipe sleeves for pipes smaller than NPS 6 (DN 150).
2) Cast-iron wall-pipe sleeves for pipes NPS 6 (DN 150) and larger.
3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

f. Sleeves for Piping Passing through Interior Concrete Walls:
1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.

12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Division 07 Section "Through-penetration Firestop Systems".

M. Sleeve Seal Installation
1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

N. Identification
1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".

O. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
a. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
c. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
d. Energize circuits to electrical equipment and devices.
e. Start and run excess-pressure pumps.
f. Coordinate with fire-alarm tests. Operate as required.
g. Coordinate with fire-pump tests. Operate as required.
h. Verify that equipment hose threads are same as local fire-department equipment.
3. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

4. Prepare test and inspection reports.

P. Cleaning
1. Clean dirt and debris from sprinklers.
2. Remove and replace sprinklers with paint other than factory finish.

Q. Piping Schedule
1. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded **OR** grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved, **as directed**, joints.
2. Sprinkler specialty fittings may be used, downstream of control vales, instead of specified fittings.
3. Copper-tube, extruded-tee connections may be used for tee branches in copper tubing instead of specified copper fittings. Branch-connection joints must be brazed.
4. CPVC pipe; Schedule 40 **OR** Schedule 80, **as directed**, CPVC fittings; and solvent-cemented joints may be used for light-hazard and residential occupancies.
5. Standard-pressure, wet-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:
   a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   c. Standard-weight or Schedule 30, black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
   d. Standard-weight or Schedule 30, galvanized-steel pipe with plain ends; galvanized, plain-end-pipe fittings; and twist-locked joints.
   e. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   f. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   g. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   h. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   i. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
   j. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
   k. Schedule 5 steel pipe; steel pressure-seal fittings; and pressure-sealed joints.
   l. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   m. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
   n. NPS 2 (DN 50), Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
6. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
   a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.

c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
f. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
g. Thinwall **OR** Schedule 10, **as directed**, nonstandard OD, thinwall or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
i. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
j. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.

7. Standard-pressure, wet-pipe sprinkler system, NPS 5 (DN 125) and larger, shall be one of the following:
   a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   f. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   g. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
   h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   i. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
8. High-pressure, wet-pipe sprinkler system, NPS 4 (DN 100) and smaller, shall be one of the following:
   a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   c. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   d. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
9. High-pressure, wet-pipe sprinkler system, NPS 5 (DN 125) and larger, shall be one of the following:

a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
c. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
d. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.

R. Sprinkler Schedule
1. Use sprinkler types in subparagraphs below for the following applications:
a. Rooms without Ceilings: Upright sprinklers.
b. Rooms with Suspended Ceilings: Pendent sprinklers **OR** Recessed sprinklers **OR** Flush sprinklers **OR** Concealed sprinklers, **as directed**.
c. Wall Mounting: Sidewall sprinklers.
d. Spaces Subject to Freezing: Upright sprinklers **OR** Pendent, dry sprinklers **OR** Sidewall, dry sprinklers, **as directed**.
e. Deluge-Sprinkler Systems: Upright and pendent, open sprinklers.
f. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers where indicated.
2. Provide sprinkler types in subparagraphs below with finishes indicated.
a. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
b. Flush Sprinklers: Bright chrome, with painted white escutcheon.
c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
d. Residential Sprinklers: Dull chrome.
e. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 13930

SECTION 13935 - DRY-PIPE FIRE-SUPPRESSION SPRINKLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for dry-pipe fire-suppression sprinklers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Pipes, fittings, and specialties.
b. Fire-protection valves.
c. Fire-department connections.
d. Sprinkler specialty pipe fittings.
e. Sprinklers.
f. Alarm devices.
g. Manual control stations.
h. Control panels.
i. Pressure gages.

C. Definitions
1. Standard-Pressure Sprinkler Piping: Dry-pipe sprinkler system piping designed to operate at working pressure 175 psig (1200 kPa) maximum.

D. System Descriptions
1. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from sprinklers that are open.
2. Combined Dry-Pipe and Preaction Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Fire-detection system in same area as sprinklers actuates tripping devices that open dry-pipe valve without loss of air pressure and actuates fire alarm. Water discharges from sprinklers that have opened.
3. Single-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing low-pressure air. Actuation of fire-detection system in same area as sprinklers opens deluge valve, permitting water to flow into piping and to discharge from sprinklers that have opened.
4. Double-Interlock Preaction Sprinkler System: Automatic sprinklers are attached to piping containing low-pressure air. Actuation of a fire-detection system in the same area as sprinklers opens the deluge valve permitting water to flow into the sprinkler piping; a closed solenoid valve in the sprinkler piping is opened by another fire-detection device; then water will discharge from sprinklers that have opened.

E. Performance Requirements
1. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
2. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Sprinkler system design shall be approved by authorities having jurisdiction.
a. Margin of Safety for Available Water Flow and Pressure: 10 **OR** 20, **as directed**, percent, including losses through water-service piping, valves, and backflow preventers.
b. Sprinkler Occupancy Hazard Classifications:
1) Automobile Parking Areas: Ordinary Hazard, Group 1.

2) Building Service Areas: Ordinary Hazard, Group 1.
3) Churches: Light Hazard.
4) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
5) Dry Cleaners: Ordinary Hazard, Group 2.
6) General Storage Areas: Ordinary Hazard, Group 1.
7) Laundries: Ordinary Hazard, Group 1.
8) Libraries Except Stack Areas: Light Hazard.
9) Library Stack Areas: Ordinary Hazard, Group 2.
10) Machine Shops: Ordinary Hazard, Group 2.
11) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
12) Office and Public Areas: Light Hazard.
13) Plastics Processing Areas: Extra Hazard, Group 2.
14) Printing Plants: Extra Hazard, Group 1.
15) Repair Garages: Ordinary Hazard, Group 2.
16) Restaurant Service Areas: Ordinary Hazard, Group 1.
17) Solvent Cleaning Areas: Extra Hazard, Group 2.
18) Upholstering Plants: Extra Hazard, Group 1.

c. Minimum Density for Automatic-Sprinkler Piping Design:
1) Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
2) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
3) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.
4) Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. (12.2 mm/min. over 232-sq. m) area.
5) Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. (16.3 mm/min. over 232-sq. m) area.
6) Special Occupancy Hazard: As determined by authorities having jurisdiction.

d. Maximum Protection Area per Sprinkler: Per UL listing.
OR
Maximum Protection Area per Sprinkler:
1) Office Spaces: 120 sq. ft. (11.1 sq. m) **OR** 225 sq. ft. (20.9 sq. m), **as directed**.
2) Storage Areas: 130 sq. ft. (12.1 sq. m).
3) Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
4) Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
5) Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

e. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
1) Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
2) Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.
3) Extra-Hazard Occupancies: 500 gpm (31.5 L/s) for 90 to 120 minutes.

4. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

F. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For dry-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.
a. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Qualification Data: For qualified Installer and professional engineer, **as directed**.

5. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
6. Fire-hydrant flow test report.
7. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
8. Field quality-control reports.
9. Operation and maintenance data.

G. Quality Assurance
1. Installer Qualifications:
   a. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
      1) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
   a. NFPA 13, "Installation of Sprinkler Systems."
   b. NFPA 13R, "Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height."
   c. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

H. Project Conditions
1. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of sprinkler service.
   b. Do not proceed with interruption of sprinkler service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials
1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Steel Pipe And Fittings
1. Standard Weight, Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
2. Schedule 30, Galvanized-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
3. Thinwall Galvanized-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
5. Galvanized, Steel Couplings: ASTM A 865, threaded.
6. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
7. Malleable- or Ductile-Iron Unions: UL 860.
8. Cast-Iron Flanges: ASME B16.1, Class 125.

9. Plain-End-Pipe Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn or screwed retainer pin to secure pipe in fitting.
10. Grooved-Joint, Steel-Pipe Appurtenances:
    a. Pressure Rating: 175 psig (1200 kPa) **OR** 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**, minimum.
    b. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
    c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

C. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.
2. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
3. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
6. Copper Pressure-Seal Fittings:
    a. Standard: UL 213.
    b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
    c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze fitting with EPDM-rubber O-ring seal in each end.
7. Grooved-Joint, Copper-Tube Appurtenances:
    a. Grooved-End, Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.
    b. Grooved-End-Tube Couplings: To fit copper tube, with dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.
8. Copper-Tube, Extruded-Tee Connections:
    a. Description: Tee formed in copper tube according to ASTM F 2014.

D. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
    a. Class 125, Cast-Iron and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
    b. Class 250, Cast-Iron and Class 300, Raised-Face Flanges: Ring-type gaskets.
2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

E. Listed Fire-Protection Valves
1. General Requirements:
    a. Valves shall be UL listed or FM approved.
    b. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
2. Ball Valves:
    a. Standard: UL 1091 except with ball instead of disc.
    b. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
    c. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
    d. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.

F. Bronze Butterfly Valves:

a. Standard: UL 1091.
b. Pressure Rating: 175 psig (1200 kPa).
c. Body Material: Bronze.
d. End Connections: Threaded.

G. Iron Butterfly Valves:
a. Standard: UL 1091.
b. Pressure Rating: 175 psig (1200 kPa).
c. Body Material: Cast or ductile iron.
d. Style: Lug or wafer.
OR
End Connections: Grooved.

H. Check Valves:
a. Standard: UL 312
b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Type: Swing check.
d. Body Material: Cast iron.
e. End Connections: Flanged or grooved.

2. Bronze OS&Y Gate Valves:
a. Standard: UL 262.
b. Pressure Rating: 175 psig (1200 kPa).
c. Body Material: Bronze.
d. End Connections: Threaded.

3. Iron OS&Y Gate Valves:
a. Standard: UL 262.
b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast or ductile iron.
d. End Connections: Flanged or grooved.

4. Indicating-Type Butterfly Valves:
a. Standard: UL 1091.
b. Pressure Rating: 175 psig (1200 kPa) minimum.
c. Valves NPS 2 (DN 50) and Smaller:
1) Valve Type: Ball or butterfly.
2) Body Material: Bronze.
3) End Connections: Threaded.
d. Valves NPS 2-1/2 (DN 65) and Larger:
1) Valve Type: Butterfly.
2) Body Material: Cast or ductile iron.
3) End Connections: Flanged, grooved, or wafer.
e. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch **OR** electrical, 115-V ac, prewired, two-circuit, supervisory switch **OR** visual, **as directed**, indicating device.

5. NRS Gate Valves:
a. Standard: UL 262.
b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast iron with indicator post flange.
d. Stem: Nonrising.
e. End Connections: Flanged or grooved.

6. Indicator Posts:
a. Standard: UL 789.
b. Type: Horizontal for wall mounting.
c. Body Material: Cast iron with extension rod and locking device.
d. Operation: Wrench **OR** Hand wheel, **as directed**.

I. Trim And Drain Valves

1. General Requirements:
   a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   b. Pressure Rating: 175 psig (1200 kPa) minimum.
2. Angle Valves.
3. Ball Valves.
4. Globe Valves.
5. Plug Valves.

J. Specialty Valves
1. General Requirements:
   a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   b. Pressure Rating:
      1) Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
      2) High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Body Material: Cast or ductile iron.
   d. Size: Same as connected piping.
   e. End Connections: Flanged or grooved.
2. Dry-Pipe Valves:
   a. Standard: UL 260
   b. Design: Differential-pressure type.
   c. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
   d. Air-Pressure Maintenance Device:
      1) Standard: UL 260.
      2) Type: Automatic device to maintain minimum air pressure in piping.
      3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.
   e. Air Compressor:
      1) Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
      2) Motor Horsepower: Fractional.
      3) Power: 120-V ac, 60 Hz, single phase.
3. Deluge Valves:
   a. Standard: UL 260.
   b. Design: Hydraulically operated, differential-pressure type.
   c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
   d. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gages; low-air-pressure warning switch; air relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.
   e. Air-Pressure Maintenance Device:
      1) Standard: UL 260.
      2) Type: Automatic device to maintain minimum air pressure in piping.
      3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure,

strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.

f. Air Compressor:
   1) Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   2) Motor Horsepower: Fractional.
   3) Power: 120-V ac, 60 Hz, single phase.

4. Automatic (Ball Drip) Drain Valves:
   a. Standard: UL 1726.
   b. Pressure Rating: 175 psig (1200 kPa) minimum.
   c. Type: Automatic draining, ball check.
   d. Size: NPS 3/4 (DN 20).
   e. End Connections: Threaded.

K. Fire-Department Connections
1. Exposed-Type, Fire-Department Connection:
   a. Standard: UL 405.
   b. Type: Exposed, projecting, for wall mounting.
   c. Pressure Rating: 175 psig (1200 kPa) minimum.
   d. Body Material: Corrosion-resistant metal.
   e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
   f. Caps: Brass, lugged type, with gasket and chain.
   g. Escutcheon Plate: Round, brass, wall type.
   h. Outlet: Back, with pipe threads.
   i. Number of Inlets: Two **OR** Three, **as directed**.
   j. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
   k. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
   l. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
2. Flush-Type, Fire-Department Connection:
   a. Standard: UL 405.
   b. Type: Flush, for wall mounting.
   c. Pressure Rating: 175 psig (1200 kPa) minimum.
   d. Body Material: Corrosion-resistant metal.
   e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
   f. Caps: Brass, lugged type, with gasket and chain.
   g. Escutcheon Plate: Rectangular, brass, wall type.
   h. Outlet: With pipe threads.
   i. Body Style: Horizontal **OR** Square **OR** Vertical, **as directed**.
   j. Number of Inlets: Two **OR** Three **OR** Four **OR** Six, **as directed**.
   k. Outlet Location: Back **OR** Bottom **OR** Left side **OR** Right side **OR** Top, **as directed**.
   l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
   m. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
   n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**.
3. Yard-Type, Fire-Department Connection:
   a. Standard: UL 405.
   b. Type: Exposed, freestanding.
   c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.

d. Body Material: Corrosion-resistant metal.
e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
f. Caps: Brass, lugged type, with gasket and chain.
g. Escutcheon Plate: Round, brass, floor type.
h. Outlet: Bottom, with pipe threads.
i. Number of Inlets: Two **OR** Three **OR** Four, **as directed**.
j. Sleeve: Brass **OR** Not required, **as directed**.
k. Sleeve Height: 18 inches (460 mm).
l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "AUTO SPKR", **as directed**.
m. Finish, Including Sleeve: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.

L. Sprinkler Specialty Pipe Fittings
1. General Requirements for Dry-Pipe-System Fittings: UL listed for dry-pipe service.
2. Branch Outlet Fittings:
a. Standard: UL 213.
b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
d. Type: Mechanical-T and -cross fittings.
e. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
f. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
g. Branch Outlets: Grooved, plain-end pipe, or threaded.
3. Flow Detection and Test Assemblies:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
d. Size: Same as connected piping.
e. Inlet and Outlet: Threaded.
4. Branch Line Testers:
a. Standard: UL 199.
b. Pressure Rating: 175 psig (1200 kPa) minimum.
c. Body Material: Brass.
d. Size: Same as connected piping.
e. Inlet: Threaded.
f. Drain Outlet: Threaded and capped.
g. Branch Outlet: Threaded, for sprinkler.
5. Sprinkler Inspector's Test Fittings:
a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
b. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Cast- or ductile-iron housing with sight glass.
d. Size: Same as connected piping.
e. Inlet and Outlet: Threaded.
6. Adjustable Drop Nipples:
a. Standard: UL 1474.
b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
c. Body Material: Steel pipe with EPDM O-ring seals.
d. Size: Same as connected piping.
e. Length: Adjustable.

f. Inlet and Outlet: Threaded.

7. Flexible, Sprinkler Hose Fittings:
   a. Standard: UL 1474.
   b. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
   c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   d. Size: Same as connected piping, for sprinkler.

M. Sprinklers
1. General Requirements:
   a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   b. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
   c. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
   d. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
2. Automatic Sprinklers with Heat-Responsive Element:
   a. Nonresidential Applications: UL 199.
   b. Residential Applications: UL 1626.
   c. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with discharge coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
3. Sprinkler Finishes:
   a. Chrome plated.
   b. Bronze.
   c. Painted.
4. Special Coatings:
   a. Wax.
   b. Lead.
   c. Corrosion-resistant paint.
5. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   a. Ceiling Mounting: Chrome-plated steel, one piece, flat **OR** Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment **OR** Plastic, white finish, one piece, flat, **as directed**.
   b. Sidewall Mounting: Chrome-plated steel **OR** Plastic, white finish, **as directed**, one piece, flat.
6. Sprinkler Guards:
   a. Standard: UL 199.
   b. Type: Wire cage with fastening device for attaching to sprinkler.

N. Alarm Devices
1. Alarm-device types shall match piping and equipment connections.
2. Water-Motor-Operated Alarm:
   a. Standard: UL 753.
   b. Type: Mechanically operated, with Pelton wheel.
   c. Alarm Gong: Cast aluminum with red-enamel factory finish.
   d. Size: 10-inch (250-mm) diameter.
   e. Components: Shaft length, bearings, and sleeve to suit wall construction.
   f. Inlet: NPS 3/4 (DN 20).
   g. Outlet: NPS 1 (DN 25) drain connection.
3. Electrically Operated Alarm Bell:
   a. Standard: UL 464.
   b. Type: Vibrating, metal alarm bell.

c. Size: 6-inch (150-mm) minimum **OR** 8-inch (200-mm) minimum **OR** 10-inch (250-mm), **as directed**, diameter.
d. Finish: Red-enamel factory finish, suitable for outdoor use.

4. Pressure Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised water-flow switch with retard feature.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design Operation: Rising pressure signals water flow.
5. Valve Supervisory Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design: Signals that controlled valve is in other than fully open position.
6. Indicator-Post Supervisory Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design: Signals that controlled indicator-post valve is in other than fully open position.

O. Manual Control Stations
1. Description: UL listed or FM Global approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

P. Control Panels
1. Description: Single-area, two-area, or single-area cross-zoned type control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire-alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.

2. Panels: UL listed and FM Global approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
   a. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
      OR
      Manual Control Stations: Hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

Q. Pressure Gages
1. Standard: UL 393.
2. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
3. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum **OR** 0 to 300 psig (0 to 2070 kPa), **as directed**.
4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
5. Air System Piping Gage: Include retard feature, **as directed**, and "AIR" or "AIR/WATER" label on dial face.

R. Escutcheons
1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

2. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with set-screws.
3. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.
4. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw or spring clips.
5. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with concealed hinge and set-screw.
6. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, set-screw or spring clips.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.
8. Split-Casting Floor Plates: Cast brass with concealed hinge.

S. Sleeves
1. Cast-Iron Wall Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set-screws.

T. Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

U. Grout
1. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink, and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Preparation
1. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
2. Report test results promptly and in writing.

B. Service-Entrance Piping
1. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements in Division 02 Section "Facility Fire-suppression Water-service Piping" for exterior piping.

2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with requirements in Division 02 Section "Facility Fire-suppression Water-service Piping" for backflow preventers, **as directed**.
3. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

C. Water-Supply Connections
1. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements in Division 15 Section "Domestic Water Piping" for interior piping.
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories indicated at connection to water-distribution piping. Comply with requirements in Division 15 Section "Domestic Water Piping Specialties" for backflow preventers, **as directed**.
3. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. Piping Installation
1. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   a. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Owner before deviating from approved working plans.
2. Piping Standard: Comply with requirements in NFPA 13 for installation of sprinkler piping.
3. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
4. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
5. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
6. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
7. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
8. Install sprinkler piping with drains for complete system drainage.
9. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
10. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or to outside building.
11. Connect compressed-air supply to dry-pipe sprinkler piping.
    OR
    Connect air compressor to the following piping and wiring:
    a. Pressure gages and controls.
    b. Electrical power system.
    c. Fire-alarm devices, including low-pressure alarm.
12. Install alarm devices in piping systems.
13. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13 for hanger materials.
14. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
15. Drain dry-pipe sprinkler piping.
16. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices **OR** air compressors, **as directed**.

E. Joint Construction

1. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
2. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
3. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
4. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
5. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
6. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
7. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
8. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
9. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
10. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
11. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
12. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.
13. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
14. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

F. Valve And Specialties Installation
1. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
2. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
3. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
4. Specialty Valves:
   a. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
   b. Dry-Pipe and Deluge Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
      1) Install air compressor and compressed-air supply piping.
      2) Air-Pressure Maintenance Device: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range; and 175-psig (1200-kPa) maximum inlet pressure.
      3) Install compressed-air supply piping from building's compressed-air piping system.

G. Sprinkler Installation
   1. Install sprinklers in suspended ceilings in center of narrow dimension of, **as directed**, acoustical ceiling panels.
   2. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
   3. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

H. Fire-Department Connection Installation
   1. Install wall-type, fire-department connections.
   2. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-place Concrete".
      a. Install two **OR** three, **as directed**, protective pipe bollards around **OR** on sides of, **as directed**, each fire-department connection. Comply with requirements for bollards in Division 05 Section "Metal Fabrications".
   3. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

I. Escutcheon Installation
   1. Install escutcheons for penetrations of walls, ceilings, and floors.
   2. Escutcheons for New Piping:
      a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
      b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set-screw **OR** stamped steel with set-screw or spring clips **OR** stamped steel with spring clips, **as directed**.
      c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set-screw **OR** One piece or split plate, stamped steel with set-screw **OR** Split plate, stamped steel with set-screw, **as directed**.
      d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
      e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
      f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
   3. Escutcheons for Existing Piping:
      a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
      b. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.
      c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
      d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set-screw, **as directed**.
      e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set-screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set-screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set-screw or spring clips, **as directed**.
      f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set-screw or spring clips, **as directed**.
      g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

J. Sleeve Installation
1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
2. Sleeves are not required for core-drilled holes.
3. Permanent sleeves are not required for holes formed by removable PE sleeves.
4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
5. Install sleeves in new partitions, slabs, and walls as they are built.
6. For interior wall penetrations, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.
9. Seal space outside of sleeves in concrete slabs and walls with grout.
10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe unless otherwise indicated.
11. Install sleeve materials according to the following applications:
    a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
    b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe **OR** Stack sleeve fittings, **as directed**.
        1) Extend sleeves 2 inches (50 mm) above finished floor level.
        2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements for flashing in Division 07 Section "Sheet Metal Flashing And Trim".
    c. Sleeves for Piping Passing through Gypsum-Board Partitions:
        1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
        2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
        3) Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
    d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
    e. Sleeves for Piping Passing through Exterior Concrete Walls:
        1) Galvanized-steel-pipe sleeves for pipes smaller than NPS 6 (DN 150).
        2) Cast-iron wall pipe sleeves for pipes NPS 6 (DN 150) and larger.
        3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe when sleeve seals are used.
    f. Sleeves for Piping Passing through Interior Concrete Walls:
        1) PVC-pipe **OR** Galvanized-steel pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
        2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems" for firestop materials and installations.

K. Sleeve Seal Installation
1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe

and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

L. Identification
1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".

M. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
   b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   c. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
   d. Energize circuits to electrical equipment and devices.
   e. Start and run air compressors.
   f. Coordinate with fire-alarm tests. Operate as required.
   g. Coordinate with fire-pump tests. Operate as required.
   h. Verify that equipment hose threads are same as local fire-department equipment.
3. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

N. Cleaning
1. Clean dirt and debris from sprinklers.
2. Remove and replace sprinklers with paint other than factory finish.

O. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

P. Piping Schedule
1. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded **OR** grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved, **as directed**, joints.
2. Sprinkler specialty fittings may be used, downstream of control vales, instead of specified fittings.
3. Copper-tube, extruded-tee connections may be used for tee branches in copper tubing instead of specified copper fittings. Branch-connection joints must be brazed.
4. Standard-pressure, dry-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:
   a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight **OR** Schedule 30 **OR** thinwall, **as directed**, galvanized-steel pipe with plain ends; plain-end-pipe fittings; and twist-locked joints.
   c. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   e. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
   f. NPS 2 (DN 50), Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.

5. Standard-pressure, dry-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
   a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; copper pressure-seal fittings; and pressure-sealed joints.
   e. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
6. Standard-pressure, dry-pipe sprinkler system, NPS 5 and NPS 6 (DN 125 and DN 150), shall be one of the following:
   a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.

Q. Sprinkler Schedule
1. Use sprinkler types in subparagraphs below for the following applications:
   a. Rooms without Ceilings: Upright sprinklers.
   b. Rooms with Suspended Ceilings: Dry pendent sprinklers **OR** Dry recessed sprinklers **OR** Dry flush sprinklers **OR** Dry concealed sprinklers, **as directed**.
   c. Wall Mounting: Dry sidewall sprinklers.
   d. Spaces Subject to Freezing: Upright sprinklers **OR** Dry pendent sprinklers **OR** Dry sidewall sprinklers**, as directed**.
   e. Special Applications: Extended-coverage and quick-response sprinklers where indicated.
2. Provide sprinkler types in subparagraphs below with finishes indicated.
   a. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
   b. Flush Sprinklers: Bright chrome, with painted white escutcheon.
   c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
   d. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 13935

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SECTION 13965 - CLEAN-AGENT EXTINGUISHING SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for clean-agent extinguishing systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes clean-agent extinguishing systems and the following:
   a. Piping and piping specialties.
   b. Extinguishing-agent containers.
   c. Extinguishing agent.
   d. Detection and alarm devices.
   e. Control and alarm panels.
   f. Accessories.
   g. Connection devices for and wiring between system components.
   h. Connection devices for power and integration into building's fire alarm system.

C. Definitions
1. ATS: Acceptance Testing Specifications.
2. EPO: Emergency Power Off.

D. System Description
1. Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area including the room cavity below the ceiling and below the raised floor. Provide separate zones above and below the raised floor. If smoke is detected below the raised floor, agent shall be discharged in the underfloor zone only. If smoke is detected above the raised floor, agent shall be discharged in zones above and below the floor.

E. Performance Requirements
1. Design clean-agent extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A, B, or C fires as appropriate for areas being protected and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.
2. Performance Requirements: Discharge HFC 227ea within 10 seconds and maintain 7.1 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.
   a. HFC 227ea concentration in hazard areas greater than 9.0 percent immediately after discharge or less than 5.8 percent throughout holding time will not be accepted without written authorization from Owner and authorities having jurisdiction.
   b. System Capabilities: Minimum 620-psig (4278-kPa) calculated working pressure and 360-psig (2484-kPa) initial charging pressure.
3. Performance Requirements: Discharge IG-541 within 60 seconds and maintain 38 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.
   a. IG-541 concentration in hazard areas greater than 40 percent immediately after discharge or less than 32 percent throughout holding time will not be accepted without written authorization from Owner and authorities having jurisdiction.
   b. System Capabilities: Minimum 2175-psig (15-MPa) calculated working pressure upstream from orifice union, minimum 1000-psig (6895-kPa) calculated working pressure downstream from orifice union, and 2175-psig (15-MPa) initial charging pressure.

4. Cross-Zoned Detection: Devices located in two separate zones. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating single-detection device in other zone.
   OR
   Verified Detection: Devices located in single zone. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating second-detection device.
5. System Operating Sequence: As follows:
   a. Actuating First Detector: Visual indication on annunciator panel, energize audible alarm and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire alarm system.
   b. Actuating Second Detector: Visual indication on annunciator panel, energize audible and visual alarms (fast pulse), shut down power to protected equipment, start time delay for extinguishing-agent discharge for 30 seconds, and discharge extinguishing agent. On agent discharge, release preaction valve to allow water to fill sprinkler system.
   c. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.
6. System Operating Sequence: System shall be cross-zoned, air-sampling detectors and photoelectric detectors reporting to a fully programmable microprocessor-based control panel programmed to operate as follows:
   a. If one photoelectric detector and air-sampling detector reaches the third detection level (Fire 1), agent discharge will be initiated as described for the third detection level (Fire 1) below.
   b. Air-Sampling System:
      1) First Detection Level (Alert): Mild audible and visual indication on annunciator panel. Strobe lights flash slowly in the protected area.
      2) Second Detection Level (Action): Strong audible and visual indication on annunciator panel. Strobe lights flash rapidly in the protected area.
      3) Third Detection Level (Fire 1): Strong audible and visual indication on annunciator panel. Energize horn(s), bell(s), and strobe light(s) in the protected area and outside entry doors. Shut down air-conditioning and ventilating systems serving the protected area, and close doors in the protected area. Send signal to fire alarm system, initiate 30-second time delay for extinguishing-agent discharge, and discharge extinguishing agent. At agent discharge, terminate power to equipment in the protected area, and release preaction valve to allow water flow to sprinkler system.
      4) Fourth Detection Level (Fire 2): Same as Fire 1.
7. Manual stations shall immediately discharge extinguishing agent when activated.
8. Operating abort switches will delay extinguishing-agent discharge while being activated, and switches must be reset to prevent agent discharge. Release of hand pressure on the switch will cause agent discharge if the time delay has expired.
9. EPO: Will terminate power to protected equipment immediately on actuation.
10. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.
11. Power Transfer Switch: Transfer from normal to stand-by power source.
12. Seismic Performance: Fire-suppression piping and containers shall be capable of withstanding the effects of earthquake motions determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

F. Submittals
   1. Product Data: For each product indicated.
   2. LEED Submittal:
      a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that clean agents comply.
   3. Shop Drawings: Signed and sealed by a qualified professional engineer. Include design calculations.

4. Permit Approved Drawings: Working plans, prepared according to NFPA 2001, that have been approved by authorities having jurisdiction. Include design calculations.
5. Field quality-control test reports.
6. Maintenance Data: For components to include in maintenance manuals.

G. Quality Assurance
1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of clean-agent extinguishing systems that are similar to those indicated for this Project in material, design, and extent.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Piping Materials
1. Refer to Part 1.3 piping applications Article retained for applications of pipe, tube, fitting, and joining materials.
2. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.

B. Pipe And Fittings
1. Steel Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106, Grade B; Schedule 40, or Schedule 80, seamless steel pipe.
   a. Threaded Fittings:
      1) Malleable-Iron Fittings: ASME B16.3, Class 300.
      2) Flanges and Flanged Fittings: ASME B16.5, Class 300, unless Class 600 is indicated.
   b. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
   c. Grooved-End Fittings: FMG approved and NRTL listed, ASTM A 47/A 47M malleable iron or ASTM A 536 ductile iron, with dimensions matching steel pipe and ends factory grooved according to AWWA C606.

   Plain-End, Hard Copper Tube: ASTM B 88, Type K **OR** L, **as directed**, (ASTM B 88M, Type A **OR** B, **as directed**,), water tube, drawn temper.
   d. Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper alloy, pressure.
   e. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 300.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, unless thickness or specific material is indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
4. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing.
5. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
6. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A 536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

C. Valves
1. General: Brass; suitable for intended operation.
2. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.

3. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.
4. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

D. Extinguishing-Agent Containers
1. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.
   a. Finish: Red **OR** Manufacturer's standard color, **as directed**, enamel or epoxy paint.
   b. Manifold: Fabricate with valves, pressure switches, and connections for multiple storage containers, as indicated.
      OR
      Manifold: Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
   c. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

E. Fire-Extinguishing Clean Agent
1. Clean Agent: HFC 227ea, heptafluoropropane.
   OR
   Clean Agent: IG-541, mixture of nitrogen, argon, and carbon dioxide inert gases.

F. Discharge Nozzles
1. Equipment manufacturer's standard one-piece brass or aluminum alloy of type, discharge pattern, and capacity required for application.

G. Manifold And Orifice Unions
1. Description: NRTL-listed device with minimum 2175-psig (15-MPa) pressure rating, to control flow and reduce pressure of IG-541 gas in piping.
   a. NPS 2 (DN 50) and Smaller: Piping assembly with orifice, sized for system design requirements.
   b. NPS 2-1/2 (DN 65) and Larger: Piping assembly with nipple, sized for system design requirements.

H. Control Panels
1. Description: FMG approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.
2. Power Requirements: 120/240-V ac; with electrical contacts for connection to system components and fire alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.
3. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.
   a. Mounting: Recessed flush with surface **OR** Surface, **as directed**.
4. Supervised Circuits: Separate circuits for each independent hazard area.
   a. Detection circuits equal to the required number of zones, or addressable devices assigned to the required number of zones.
   b. Manual pull-station circuit.
   c. Alarm circuit.
   d. Release circuit.
   e. Abort circuit.
   f. EPO circuit.
5. Provide the following control-panel features:
   a. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.

b. Automatic switchover to standby power at loss of primary power.
c. Storage container, low-pressure indicator.
d. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.

6. Annunciator Panel: Graphic type showing protected, hazard-area plans and locations of detectors, abort, EPO, and manual stations. Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless-steel or aluminum enclosure.
7. Standby Power: Lead-acid or nickel-cadmium batteries with capacity to operate system for 72 hours and alarm for minimum of 15 minutes. Include automatic battery charger, with varying charging rate between trickle and high depending on battery voltage, that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, and suitable enclosure.

I. Detection Devices
1. Description: Comply with NFPA 2001 and NFPA 72, and include the following types:
a. Ionization Detectors: Comply with UL 268, dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.
b. Photoelectric Detectors: Comply with UL 268, consisting of LED light source and silicon photodiode receiving element.
c. Remote Air-Sampling Detector System: Includes air-sampling pipe network, a laser-based photoelectric detector, a sample transport fan, and a control unit.
1) Comply with UL 268 and NRTL listed, operating at 24-V dc, nominal.
2) Pipe Network: CPVC tubing connects control unit with calibrated sampling holes.
3) Smoke Detector: Particle-counting type with continuous laser beam. Sensitivity adjustable to a minimum of four preset values.
4) Sample Transport Fan: Centrifugal type, creating a minimum static pressure of 0.05-inch wg (12.5 Pa) at all sampling ports.
5) Control Unit: Multizone unit as indicated on Drawings. Provides same system power supply, supervision, and alarm features as specified for the control panel plus separate trouble indication for airflow and detector problems.
6) Signals to the Central Fire Alarm Control Panel: Any type of local system trouble is reported to the central fire alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to the central fire alarm control panel as separately identified zones.

J. Manual Stations
1. General Description: Surface **OR** Semirecessed, **as directed**, FMG approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
2. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.
3. Abort Switch: "ABORT" caption, momentary contact, with green finish.
4. EPO Switch: "EPO" caption, with yellow finish.

K. Switches
1. Description: FMG approved or NRTL listed, where available, 120-V ac or low voltage compatible with controls. Include contacts for connection to control panel.
a. Low-Agent Pressure Switches: Pneumatic operation.
b. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.
c. Door Closers: Magnetic retaining and release device or electrical interlock to cause the door operator to drive the door closed.

L. Alarm Devices
1. Description: FMG approved or NRTL listed, low voltage, and surface mounting, unless otherwise indicated.

2. Bells: Minimum 6-inch (150-mm) diameter.
3. Horns: 90 to 94 dBA.
4. Strobe Lights: Translucent lens, with "FIRE" or similar caption.

M. Electrical Power And Wiring
1. Electrical power, wiring, and devices are specified in Division 15.

1.3 EXECUTION

A. Piping Applications
1. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
2. Fittings Working Pressure: 620 psig (4278 kPa) minimum.
3. Flanged Joints: Class 300 minimum.
4. NPS 2 (DN 50) and Smaller: ASTM B 88, Type K **OR** L, **as directed**, (ASTM B 88M, Type A **OR** B, **as directed**,) copper tube; copper, solder-joint fittings; and brazed joints.
OR
NPS 2 (DN 50) and Smaller: Schedule 40, steel pipe; malleable-iron threaded fittings; and threaded joints.
5. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): ASTM B 88, Type K **OR** L, **as directed**, (ASTM B 88M, Type A **OR** B, **as directed**,) copper tube; copper, solder-joint fittings; and brazed joints.
OR
NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Schedule 40, steel pipe; forged-steel welding fittings; and welded joints.
OR
NPS 2-1/2 and NPS 3 (DN 65 and DN 80): Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.
6. NPS 4 (DN 100) and Larger: Schedule 40, steel pipe; steel, grooved-end fittings; steel, keyed couplings; and grooved joints.
OR
NPS 4 (DN 100) and Larger: Schedule 40, steel pipe; forged-steel welding fittings; and welded joints.

B. Piping Applications
1. Piping between Storage Containers and Orifice Union:
a. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
b. Fittings Working Pressure: 2175 psig (15 MPa) minimum.
c. Flanged Joints: Class 600 minimum.
d. All Sizes: Schedule 80, steel pipe; forged-steel welding fittings; and welded joints.
2. Piping Downstream from Orifice Union:
a. Flanged pipe and fittings and flanged joints may be used to connect to specialties and accessories and where required for maintenance.
b. Fittings Working Pressure: 1000 psig (6900 kPa) minimum.
c. Flanged Joints: Class 300 minimum.
d. All Sizes: Schedule 40 **OR** 80, **as directed**, steel pipe; forged-steel welding fittings; and welded joints.

C. Clean-Agent Extinguishing Piping Installation
1. Install clean-agent extinguishing piping and other components level and plumb and according to manufacturers' written instructions.
2. Refer to Division 15 Section "Common Work Results For Fire Suppression" for basic pipe installation and joint construction.

3. Grooved Piping Joints: Groove pipe ends according to AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant according to manufacturer's written instructions.
4. Install extinguishing-agent containers anchored to substrate.
5. Install pipe and fittings, valves, and discharge nozzles according to requirements listed in NFPA 2001, Section "Distribution," and in ASME B31.1.
   a. Install valves designed to prevent entrapment of liquid or install pressure relief devices in valved sections of piping systems.
   b. Support piping using supports and methods according to NFPA 13.
   c. Install seismic restraints for extinguishing-agent containers and piping systems.
   d. Install control panels, detection system components, alarms, and accessories, complying with requirements of NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

D. Connections
1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to extinguishing-agent containers to allow service and maintenance.
3. Connect electrical devices to control panel and to building's fire alarm system. Electrical power, wiring, and devices are specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".

E. Labeling
1. Install labeling on piping, extinguishing-agent containers, other equipment, and panels according to NFPA 2001.
2. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire extinguishing system.
3. Install signs at entry doors to advise persons outside the room the meaning of the horn(s), bell(s), and strobe light(s) outside the protected space.

F. Field Quality Control
1. Comply with operating instructions and procedures of NFPA 2001, Section "Approval of Installations." Include the following tests and inspections to demonstrate compliance with requirements:
   a. Check mechanical items.
   b. Inspect extinguishing-agent containers and extinguishing agent, and check mountings for adequate anchoring to substrate.
   c. Check electrical systems.
   d. Check enclosure integrity. Comply with NFPA 2001, Section "Enclosure Inspection," and Appendix C, "Enclosure Integrity Procedure."
   e. Perform functional pre-discharge test.
   f. Perform system functional operational test including, EPO, abort, and manual release.
   g. Check remote monitoring operations.
   h. Check control-panel primary power source.
   i. Perform "puff" test on piping system, using nitrogen.
2. Perform field-acceptance tests of each clean-agent extinguishing system when installation is complete. Perform system testing only after hazard-area enclosure construction has been completed and openings sealed. Comply with operating instructions and procedures of NFPA 2001, Section "Approval of Installations." Include the following to demonstrate compliance with requirements:
   a. Perform functional predischarge test.
   b. Perform system functional operational test.
   c. Check remote monitoring operations.
   d. Check control-panel primary power source.
   e. Perform "puff" test on piping system, using nitrogen.

3. Correct malfunctioning equipment, then retest to demonstrate compliance. Replace equipment that cannot be corrected or does not perform as specified and indicated, then retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
   a. Report test results promptly and in writing to the Owner and authorities having jurisdiction.
4. Perform the following field tests and inspections and prepare test reports:
   a. After installing clean-agent extinguishing piping system and after electrical circuitry has been energized, test for compliance with requirements.
   b. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections "Inspection and Test Procedures" and "System Function Tests." Certify compliance with test parameters.
   c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
   e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Remove and replace malfunctioning units and retest as specified above.

G. Cleaning
1. Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free of particulate matter and oil residue before installing nozzles or discharge devices.

H. System Filling
1. Preparation:
   a. Verify that piping system installation is completed and cleaned.
   b. Check for complete enclosure integrity.
   c. Check operation of ventilation and exhaust systems.
2. Filling Procedures:
   a. Fill extinguishing-agent containers with extinguishing agent and pressurize to indicated charging pressure.
   b. Install filled extinguishing-agent containers.
   c. Energize circuits.
   d. Adjust operating controls.

I. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain clean-agent extinguishing systems.

END OF SECTION 13965

Task	Specification	Specification Description
13965	01352	No Specification Required

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SECTION 13975 - FIRE-SUPPRESSION STANDPIPES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for fire-suppression standpipes. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Pipes, fittings, and specialties.
b. Fire-protection valves.
c. Hose connections.
d. Hose stations.
e. Monitors.
f. Fire-department connections.
g. Alarm devices.
h. Manual control stations.
i. Control panels.
j. Pressure gages.

C. Definitions
1. High-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure higher than standard 175 psig (1200 kPa), but not higher than 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
2. Standard-Pressure Standpipe Piping: Fire-suppression standpipe piping designed to operate at working pressure 175 psig (1200 kPa) maximum.

D. System Descriptions
1. Automatic Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
2. Automatic Wet-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
3. Automatic Wet-Type, Class III Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations and NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve with pressure maintained and is capable of supplying water demand.
4. Automatic Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and dry-pipe valve with standpipes containing compressed air. Opening fire-hose valve releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into standpipes.
5. Automatic Dry-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve and dry-pipe valve with standpipes containing compressed air. Opening fire-hose valve releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into standpipes.
6. Automatic Dry-Type, Class III Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations and NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and dry-pipe valve with standpipes containing compressed air. Opening fire-hose valve releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into standpipes.
7. Semiautomatic Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and deluge valve with standpipes containing air.

Actuation of detection device permits water pressure to open deluge valve. Water then flows into standpipes.

8. Semiautomatic Dry-Type, Class II Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations. Has open water-supply valve and deluge valve with standpipes containing air. Actuation of detection device permits water pressure to open deluge valve. Water then flows into standpipes.
9. Semiautomatic Dry-Type, Class III Standpipe System: Includes NPS 1-1/2 (DN 40) hose stations and NPS 2-1/2 (DN 65) hose connections. Has open water-supply valve and deluge valve with standpipes containing air. Actuation of detection device permits water pressure to open deluge valve. Water then flows into standpipes.
10. Manual Wet-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Has small water supply to maintain water in standpipes. Piping is wet, but water must be pumped into standpipes to satisfy demand.
11. Manual Dry-Type, Class I Standpipe System: Includes NPS 2-1/2 (DN 65) hose connections. Does not have permanent water supply. Piping is dry. Water must be pumped into standpipes to satisfy demand.

E. Performance Requirements
1. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
2. High-Pressure, Fire-Suppression Standpipe System Component: Listed for 250-psig (1725-kPa) minimum **OR** 300-psig (2070-kPa), **as directed**, working pressure.
3. Delegated Design: Design fire-suppression standpipes, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
4. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.
   a. Minimum residual pressure at each hose-connection outlet is as follows:
      1) NPS 1-1/2 (DN 40) Hose Connections: 65 psig (450 kPa).
      2) NPS 2-1/2 (DN 65) Hose Connections: 100 psig (690 kPa).
   b. Maximum residual pressure at required flow at each hose-connection outlet is as follows unless otherwise indicated:
      1) NPS 1-1/2 (DN 40) Hose Connections: 100 psig (690 kPa).
      2) NPS 2-1/2 (DN 65) Hose Connections: 175 psig (1200 kPa).
5. Seismic Performance: Fire-suppression standpipes shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

F. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For fire-suppression standpipes. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For standpipe systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
4. Qualification Data: For qualified Installer and professional engineer.
5. Approved Standpipe Drawings: Working plans, prepared according to NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
6. Welding certificates.
7. Fire-hydrant flow test report.
8. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
9. Field quality-control reports.
10. Operation and Maintenance Data: For fire-suppression standpipes specialties to include in emergency, operation, and maintenance manuals.

G. Quality Assurance
1. Installer Qualifications:
a. Installer's responsibilities include designing, fabricating, and installing fire-suppression standpipes and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
1) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
2. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. NFPA Standards: Fire-suppression standpipe equipment, specialties, accessories, installation, and testing shall comply with NFPA 14, "Installation of Standpipe and Hose Systems."

H. Project Conditions
1. Interruption of Existing Fire-Suppression Standpipe Service: Do not interrupt fire-suppression standpipe service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fire-suppression standpipe service according to requirements indicated:
a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-suppression standpipe service.
b. Do not proceed with interruption of fire-suppression standpipe service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials
1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

B. Steel Pipe And Fittings
1. Standard Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
2. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
3. Thinwall Galvanized- and Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
5. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, thinwall, with plain ends and wall thickness less than Schedule 10.
6. Hybrid Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, lightwall, with wall thickness less than Schedule 10 and greater than Schedule 5.
7. Standard-Weight, Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, seamless steel pipe with threaded ends.
8. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.
9. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
10. Malleable- or Ductile-Iron Unions: UL 860.
11. Cast-Iron Flanges: ASME B16.1, Class 125.
12. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
13. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.

14. Grooved-Joint, Steel-Pipe Appurtenances:
    a. Pressure Rating: 175 psig (1200 kPa) **OR** 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**, minimum.
    b. Galvanized and Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
    c. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

C. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.
2. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
3. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.
4. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
5. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
6. Grooved-Joint, Copper-Tube Appurtenances:
    a. Grooved-End, Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.
    b. Grooved-End-Tube Couplings: To fit copper tube dimensions, with design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gasket suitable for hot and cold water, and bolts and nuts.

D. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
    a. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
    b. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
4. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

E. Listed Fire-Protection Valves
1. General Requirements:
    a. Valves shall be UL listed or FM approved.
    b. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
    c. Minimum Pressure Rating for High-Pressure Piping: 250 psig (1725 kPa) **OR** 300 psig (2070 kPa), **as directed**.
2. Ball Valves:
    a. Standard: UL 1091 except with ball instead of disc.
    b. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
    c. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
    d. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.
3. Bronze Butterfly Valves:
    a. Standard: UL 1091.
    b. Pressure Rating: 175 psig (1200 kPa).
    c. Body Material: Bronze.
    d. End Connections: Threaded.

4. Iron Butterfly Valves:
   a. Standard: UL 1091.
   b. Pressure Rating: 175 psig (1200 kPa).
   c. Body Material: Cast or ductile iron.
   d. Style: Lug or wafer.
      OR
      End Connections: Grooved.
5. Check Valves:
   a. Standard: UL 312.
   b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Type: Swing check.
   d. Body Material: Cast iron.
   e. End Connections: Flanged or grooved.
6. Bronze OS&Y Gate Valves:
   a. Standard: UL 262.
   b. Pressure Rating: 175 psig (1200 kPa).
   c. Body Material: Bronze.
   d. End Connections: Threaded.
7. Iron OS&Y Gate Valves:
   a. Standard: UL 262.
   b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Body Material: Cast or ductile iron.
   d. End Connections: Flanged or grooved.
8. Indicating-Type Butterfly Valves:
   a. Standard: UL 1091.
   b. Pressure Rating: 175 psig (1200 kPa) minimum.
   c. Valves NPS 2 (DN 50) and Smaller:
      1) Valve Type: Ball or butterfly.
      2) Body Material: Bronze.
      3) End Connections: Threaded.
   d. Valves NPS 2-1/2 (DN 65) and Larger:
      1) Valve Type: Butterfly.
      2) Body Material: Cast or ductile iron.
      3) End Connections: Flanged, grooved, or wafer.
   e. Valve Operation: Integral electrical, 115-V ac, prewired, single-circuit, supervisory switch **OR** electrical, 115-V ac, prewired, two-circuit, supervisory switch **OR** visual, **as directed**, indicating device.
9. NRS Gate Valves:
   a. Standard: UL 262.
   b. Pressure Rating: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Body Material: Cast iron with indicator post flange.
   d. Stem: Nonrising.
   e. End Connections: Flanged or grooved.
10. Indicator Posts:
   a. Standard: UL 789.
   b. Type: Horizontal for wall mounting.
   c. Body Material: Cast iron with extension rod and locking device.
   d. Operation: Wrench **OR** Hand wheel, **as directed**.

F. Trim And Drain Valves
1. General Requirements:
   a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   b. Pressure Rating: 175 psig (1200 kPa) minimum.
2. Angle Valves.
3. Ball Valves.

4. Globe Valves.
5. Plug Valves.

G. Specialty Valves
1. General Requirements:
   a. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
   b. Pressure Rating:
      1) Standard-Pressure Piping Specialty Valves: 175 psig (1200 kPa) minimum.
      2) High-Pressure Piping Specialty Valves: 250 psig (1725 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
   c. Body Material: Cast or ductile iron.
   d. Size: Same as connected piping.
   e. End Connections: Flanged or grooved.
2. Alarm Valves:
   a. Standard: UL 193.
   b. Design: For horizontal or vertical installation.
   c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, **as directed**, and fill-line attachment with strainer.
   d. Drip Cup Assembly (if retarding chamber is required): Pipe drain without valves and separate from main drain piping.
   e. Drip Cup Assembly (if retarding chamber is not required): Pipe drain with check valve to main drain piping.
3. Dry-Pipe Valves:
   a. Standard: UL 260.
   b. Design: Differential-pressure type.
   c. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
   d. Air-Pressure Maintenance Device:
      1) Standard: UL 260.
      2) Type: Automatic device to maintain minimum air pressure in piping.
      3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.
   e. Air Compressor:
      1) Standard: UL's "Fire Protection Equipment Directory" listing.
      2) Motor Horsepower: Fractional.
      3) Power: 120-V ac, 60 Hz, single phase.
4. Deluge Valves:
   a. Standard: UL 260.
   b. Design: Hydraulically operated, differential-pressure type.
   c. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, drip cup assembly piped without valves and separate from main drain line, fill-line attachment with strainer, and push-rod chamber supply connection.
   d. Wet, Pilot-Line Trim Set: Include gage to read push-rod chamber pressure, globe valve for manual operation of deluge valve, and connection for actuation device.
   e. Dry, Pilot-Line Trim Set: Include dry, pilot-line actuator; air- and water-pressure gages; low-air-pressure warning switch; air relief valve; and actuation device. Dry, pilot-line actuator includes cast-iron, operated, diaphragm-type valve with resilient facing plate, resilient diaphragm, and replaceable bronze seat. Valve includes threaded water and air inlets and water outlet. Loss of air pressure on dry, pilot-line side allows pilot-line actuator to open and causes deluge valve to open immediately.
   f. Air-Pressure Maintenance Device:

1) Standard: UL 260.
2) Type: Automatic device to maintain minimum air pressure in piping.
3) Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator, or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) **OR** 300-psig (2070-kPa), **as directed**, outlet pressure.

g. Air Compressor:
1) Standard: UL's "Fire Protection Equipment Directory" listing.
2) Motor Horsepower: Fractional.
3) Power: 120-V ac, 60 Hz, single phase.

5. Pressure-Reducing Valves:
a. UL 668 hose valve, with integral UL 1468 reducing device.
b. Pressure Rating: 300 psig (2070 kPa) minimum.
c. Material: Brass or bronze.
d. Inlet: Female pipe threads.
e. Outlet: Threaded with or without adapter having male hose threads.
f. Pattern: Angle or gate.
g. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.

6. Automatic (Ball Drip) Drain Valves:
a. Standard: UL 1726.
b. Pressure Rating: 175 psig (1200 kPa) minimum.
c. Type: Automatic draining, ball check.
d. Size: NPS 3/4 (DN 20).
e. End Connections: Threaded.

H. Hose Connections
1. Adjustable-Valve Hose Connections:
a. Standard: UL 668 hose valve, with integral UL 1468 reducing or restricting pressure-control device, for connecting fire hose.
b. Pressure Rating: 300 psig (2070 kPa) minimum.
c. Material: Brass or bronze.
d. Size: NPS 1-1/2 or NPS 2-1/2 (DN 40 or DN 65), as indicated.
e. Inlet: Female pipe threads.
f. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
g. Pattern: Angle or gate.
h. Pressure-Control Device Type: Pressure reducing **OR** restricting, **as directed**.
i. Design Outlet Pressure Setting: as directed by the Owner.
j. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.

2. Nonadjustable-Valve Hose Connections:
a. Standard: UL 668 hose valve for connecting fire hose.
b. Pressure Rating: 300 psig (2070 kPa) minimum.
c. Material: Brass or bronze.
d. Size: NPS 1-1/2 or NPS 2-1/2 (DN 40 or DN 65), as indicated.
e. Inlet: Female pipe threads.
f. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
g. Pattern: Angle or gate.
h. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.

I. NPS 1-1/2 (DN 40) Rack-Type Hose Stations
1. Hose Rack:
a. Standard: UL 47.

b. Material: Brass or bronze with polished chrome-plated **OR** Steel with red-enamel, **as directed**, finish.
c. Type: Hose-rack assembly. Include hose valve, hose rack, water-retention device, hose pins, and hose.
d. Operation: Semiautomatic.
e. Sized to hold fire hose.

2. Hose Valve:
   a. Standard: UL 668 NPS 1-1/2 (DN 40), for connecting fire hose.
   b. Type: Adjustable **OR** Nonadjustable, **as directed**.
   c. Pressure-Control Device: Not required **OR** Pressure reducing **OR** Pressure restricting, **as directed**.
   d. Design Outlet Pressure Setting: Not applicable **OR as directed**.
   e. Hose Valve and Trim Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
   f. Pressure Rating: 300 psig (2070 kPa) minimum.
   g. Pattern: Angle.
   h. Material: Brass or bronze.
   i. Pressure-Control Device: UL 1468 integral or for field installation if indicated.
   j. Size: NPS 1-1/2 (DN 40).
   k. Inlet: Female pipe threads.
   l. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.
3. Hose:
   a. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
   b. Size: NPS 1-1/2 (DN 40).
   c. Length: 50 feet (15 m) **OR** 75 feet (23 m) **OR** 100 feet (30 m), **as directed**.
   d. Jacket: Combination of natural and synthetic threads **OR** Natural thread **OR** Synthetic thread, **as directed**.
   e. Lining: Combination of rubber and plastic compounds **OR** Rubber compound **OR** Plastic compound, **as directed**.
   f. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
   g. Nozzle: UL 401.
      1) Material: Brass **OR** Polished brass **OR** Rough chrome-plated brass **OR** Polished chrome-plated brass **OR** Polycarbonate plastic, **as directed**.
      2) Type: Plain, for nonadjustable water stream **OR** Spray, adjustable from shutoff to fog spray or straight stream **OR** Spray, adjustable from shutoff to full fog; for use on electrical fires, **as directed**.

J. NPS 1-1/2 BY NPS 2-1/2 (DN 40 BY DN 65) Rack-Type Hose Stations
1. Hose Rack:
   a. Standard: UL 47.
   b. Material: Brass or bronze with polished chrome-plated **OR** Steel with red-enamel, **as directed**, finish.
   c. Type: Hose-rack assembly. Include hose valve, reducer adapter, hose rack, water-retention device, hose pins, and hose.
   d. Operation: Semiautomatic.
   e. Sized to hold fire hose.
2. Hose Valve:
   a. Standard: UL 668, NPS 2-1/2 (DN 65), for connecting fire hose.
   b. Type: Adjustable **OR** Nonadjustable, **as directed**.
   c. Pressure-Control Device: Not required **OR** Pressure reducing **OR** Pressure restricting, **as directed**.
   d. Design Outlet Pressure Setting: Not applicable **OR as directed**.

e. Hose Valve and Trim Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
f. Pressure Rating: 300 psig (2070 kPa) minimum.
g. Pattern: Angle.
h. Material: Brass or bronze.
i. Pressure-Control Device: UL 1468, integral or for field installation if indicated.
j. Size: NPS 2-1/2 (DN 65).
k. Inlet: Female pipe threads.
l. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.
m. Reducer Adapter: NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40).

3. Hose:
a. Standards: NFPA 1961 and UL 219, lined fire hose with swivel inlet, coupling, gaskets, and nozzle.
b. Size: NPS 1-1/2 (DN 40).
c. Length: 50 feet (15 m) **OR** 75 feet (23 m) **OR** 100 feet (30 m), **as directed**.
d. Jacket: Combination of natural and synthetic threads **OR** Natural thread **OR** Synthetic thread, **as directed**.
e. Lining: Combination of rubber and plastic compounds **OR** Rubber compound **OR** Plastic compound, **as directed**.
f. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
g. Nozzle: UL 401 spray nozzle unless plain nozzle is indicated.
1) Material: Brass **OR** Polished brass **OR** Rough chrome-plated brass **OR** Polished chrome-plated brass **OR** Polycarbonate plastic, **as directed**.
2) Type: Plain, for nonadjustable water stream **OR** Spray, adjustable from shutoff to fog spray or straight stream **OR** Spray, adjustable from shutoff to full fog; for use on electrical fires, **as directed**.

K. NPS 1-1/2 (DN 40) Reel-Type Hose Stations
1. Hose Reel:
a. Standard: UL 47.
b. Hose Reel and Bracket Material: Steel.
c. Type: Hose-reel assembly. Include hose valve, wall bracket, hose reel, water-retention device, hose pins, and hose.
d. Operation: Semiautomatic.
e. Sized to hold fire hose.
f. Finish: Red enamel.

2. Hose Valve:
a. Standard: UL 668, NPS 1-1/2 (DN 40), for connecting fire hose.
b. Type: Adjustable **OR** Nonadjustable, **as directed**.
c. Pressure-Control Device: Not required **OR** Pressure reducing **OR** Pressure restricting, **as directed**.
d. Design Outlet Pressure Setting: Not applicable **OR as directed**.
e. Hose Valve and Trim Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
f. Pressure Rating: 300 psig (2070 kPa) minimum.
g. Pattern: Angle.
h. Material: Brass or bronze.
i. Pressure-Control Device: UL 1468, integral or for field installation if indicated.
j. Size: NPS 1-1/2 (DN 40).
k. Inlet: Female pipe threads.
l. Outlet: Male hose threads according to NFPA 1963 and matching local fire-department threads.

3. Hose:
a. Standards: NFPA 1961 and UL 219 lined fire hose with swivel inlet, coupling, gaskets, and nozzle.

b. Size: NPS 1-1/2 (DN 40).
c. Length: 50 feet (15 m) **OR** 75 feet (23 m) **OR** 100 feet (30 m), **as directed**.
d. Jacket: Combination of natural and synthetic threads **OR** Natural thread **OR** Synthetic thread, **as directed**.
e. Lining: Combination of rubber and plastic compounds **OR** Rubber compound **OR** Plastic compound, **as directed**.
f. Cover: Rubber, plastic, or combination of rubber and plastic compounds.
g. Nozzle: UL 401.
   1) Material: Brass **OR** Polished brass **OR** Rough chrome-plated brass **OR** Polished chrome-plated brass **OR** Polycarbonate plastic, **as directed**.
   2) Type: Spray, adjustable from shutoff to fog spray or straight stream **OR** full fog; for use on electrical fires, **as directed**.

L. Monitors
1. Type: Stationary.
2. Nozzle: UL 401, NPS 2-1/2 (DN 65), brass, adjustable from fog spray to straight stream to shutoff.
3. Horizontal Rotation: 360 degrees with locking device.
4. Vertical Rotation: 80-degree elevation and 60-degree depression with locking device.
5. Waterway: Double **OR** Single, **as directed**, brass or stainless-steel tube.
6. Waterway Size: NPS 2-1/2 (DN 65) minimum.
7. Water Stream Flow: 500 gpm (31.5 L/s) **OR** 750 gpm (47.3 L/s) **OR** 1000 gpm (63 L/s), **as directed**.
8. Operation: Lever **OR** Wheel, **as directed**.
9. Base Inlet Size: NPS 2-1/2 (DN 65) **OR** NPS 3 (DN 80) **OR** NPS 4 (DN 100), **as directed**.
10. Finish: Red-painted body with brass trim.

M. Fire-Department Connections
1. Exposed-Type, Fire-Department Connection:
   a. Standard: UL 405.
   b. Type: Exposed, projecting, for wall mounting.
   c. Pressure Rating: 175 psig (1200 kPa) minimum.
   d. Body Material: Corrosion-resistant metal.
   e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
   f. Caps: Brass, lugged type, with gasket and chain.
   g. Escutcheon Plate: Round, brass, wall type.
   h. Outlet: Back, with pipe threads.
   i. Number of Inlets: Two **OR** Three, **as directed**.
   j. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** “STANDPIPE", **as directed**.
   k. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
   l. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.
2. Flush-Type, Fire-Department Connection:
   a. Standard: UL 405.
   b. Type: Flush, for wall mounting.
   c. Pressure Rating: 175 psig (1200 kPa) minimum.
   d. Body Material: Corrosion-resistant metal.
   e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
   f. Caps: Brass, lugged type, with gasket and chain.
   g. Escutcheon Plate: Rectangular, brass, wall type.

h. Outlet: With pipe threads.
i. Body Style: Horizontal **OR** Square **OR** Vertical, **as directed**.
j. Number of Inlets: Two **OR** Three **OR** Four **OR** Six, **as directed**.
k. Outlet Location: Back **OR** Bottom **OR** Left side **OR** Right side **OR** Top, **as directed**.
l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "STANDPIPE", **as directed**.
m. Finish: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150) **OR** NPS 8 (DN 200), **as directed**.

3. Yard-Type, Fire-Department Connection:
a. Standard: UL 405.
b. Type: Exposed, freestanding.
c. Pressure Rating: 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
d. Body Material: Corrosion-resistant metal.
e. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
f. Caps: Brass, lugged type, with gasket and chain.
g. Escutcheon Plate: Round, brass, floor type.
h. Outlet: Bottom, with pipe threads.
i. Number of Inlets: Two **OR** Three **OR** Four, **as directed**.
j. Sleeve: Brass **OR** Not required, **as directed**.
k. Sleeve Height: 18 inches (460 mm).
l. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE" **OR** "STANDPIPE", **as directed**.
m. Finish, Including Sleeve: Polished chrome plated **OR** Rough brass or bronze **OR** Rough chrome plated, **as directed**.
n. Outlet Size: NPS 4 (DN 100) **OR** NPS 5 (DN 125) **OR** NPS 6 (DN 150), **as directed**.

N. Alarm Devices
1. Alarm-device types shall match piping and equipment connections.
2. Water-Motor-Operated Alarm:
a. Standard: UL 753.
b. Type: Mechanically operated, with Pelton wheel.
c. Alarm Gong: Cast aluminum with red-enamel factory finish.
d. Size: 10-inch (250-mm) diameter.
e. Components: Shaft length, bearings, and sleeve to suit wall construction.
f. Inlet: NPS 3/4 (DN 20).
g. Outlet: NPS 1 (DN 25) drain connection.

3. Electrically Operated Alarm Bell:
a. Standard: UL 464.
b. Type: Vibrating, metal alarm bell.
c. Size: 6-inch (150-mm) minimum **OR** 8-inch (200-mm) minimum **OR** 10-inch (250-mm), **as directed**, diameter.
d. Finish: Red-enamel factory finish, suitable for outdoor use.

4. Water-Flow Indicators:
a. Standard: UL 346.
b. Water-Flow Detector: Electrically supervised.
c. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
d. Type: Paddle operated.
e. Pressure Rating: 250 psig (1725 kPa).
f. Design Installation: Horizontal or vertical.

5. Pressure Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised water-flow switch with retard feature.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design Operation: Rising pressure signals water flow.
6. Valve Supervisory Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design: Signals that controlled valve is in other than fully open position.
7. Indicator-Post Supervisory Switches:
   a. Standard: UL 346.
   b. Type: Electrically supervised.
   c. Components: Single-pole, double-throw switch with normally closed contacts.
   d. Design: Signals that controlled indicator-post valve is in other than fully open position.

O. Manual Control Stations
1. Description: UL listed or FM approved, hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

P. Control Panels
1. Description: Single-area, two-area, or single-area cross-zoned control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire-alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.
   a. Panels: UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
   b. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.
      OR
      Manual Control Stations: Hydraulic operation, with union, NPS 1/2 (DN 15) pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

Q. Pressure Gages
1. Standard: UL 393.
2. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
3. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum **OR** 0 to 300 psig (0 to 2070 kPa), **as directed**.
4. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
5. Air System Piping Gage: Include retard feature, **as directed**, and "AIR" or "AIR/WATER" label on dial face.

R. Escutcheons
1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
2. One-Piece, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with set-screws.
3. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with chrome-plated finish.

4. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw or spring clips.
5. Split-Casting, Cast-Brass Escutcheons: Polished chrome-plated or rough-brass finish with concealed hinge and set-screw.
6. Split-Plate, Stamped-Steel Escutcheons: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, set-screw or spring clips.
7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.
8. Split-Casting Floor Plates: Cast brass with concealed hinge.

S. Sleeves
1. Cast-Iron Wall-Pipe Sleeves: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, standard weight, zinc coated, plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set-screws.

T. Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

U. Grout
1. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink, and recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Preparation
1. Perform fire-hydrant flow test according to NFPA 14 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
2. Report test results promptly and in writing.

B. Service-Entrance Piping
1. Connect fire-suppression standpipe piping to water-service piping at service entrance into building. Comply with requirements for exterior piping in Division 02 Section "Facility Fire-suppression Water-service Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories at connection to fire-suppression water-service piping. Comply with requirements for backflow preventers in Division 02 Section "Facility Fire-suppression Water-service Piping", **as directed**.
3. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

C. Water-Supply Connections
1. Connect fire-suppression standpipe piping to building's interior water-distribution piping. Comply with requirements for interior piping in Division 15 Section "Domestic Water Piping".
2. Install shutoff valve, backflow preventer, **as directed**, pressure gage, drain, and other accessories at connection to water-distribution piping. Comply with requirements for backflow preventers in Division 15 Section "Domestic Water Piping Specialties", **as directed**.
   OR
   Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

D. Piping Installation
1. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
   a. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with the Owner before deviating from approved working plans.
2. Piping Standard: Comply with requirements in NFPA 14 for installation of fire-suppression standpipe piping.
3. Install seismic restraints on piping. Comply with requirements in NFPA 13 for seismic-restraint device materials and installation.
4. Install listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
5. Install drain valves on standpipes. Extend drain piping to outside of building.
6. Install automatic (ball drip) drain valves to drain piping between fire-department connections and check valves. Drain to floor drain or outside building.
7. Install alarm devices in piping systems.
8. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.
9. Install pressure gages on riser or feed main and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
10. Drain dry-type standpipe system piping.
11. Pressurize and check dry-type standpipe system piping and air-pressure maintenance devices **OR** air compressors, **as directed**.
12. Fill wet-type standpipe system piping with water.
13. Install electric heating cables and pipe insulation on wet-type, fire-suppression standpipe piping in areas subject to freezing. Comply with requirements for heating cables in Division 15 Section "Heat Tracing For Fire-suppression Piping" and for piping insulation in Division 15 Section "Fire-suppression Systems Insulation".
14. Connect compressed-air supply to dry-pipe sprinkler piping.
    OR
    Connect air compressor to the following piping and wiring:
    a. Pressure gages and controls.
    b. Electrical power system.
    c. Fire-alarm devices, including low-pressure alarm.

E. Joint Construction
1. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
2. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
3. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
4. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

5. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
6. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
7. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
8. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
9. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
10. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
    a. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
11. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
12. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
13. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

F. Valve And Specialties Installation
1. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 14 and authorities having jurisdiction.
2. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
3. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
4. Specialty Valves:
   a. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
   b. Alarm Valves: Install bypass check valve and retarding chamber drain-line connection.
   c. Dry-Pipe and Deluge Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
      1) Install air compressor and compressed-air supply piping.
         OR
         Air-Pressure Maintenance Device: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig (95- to 410-kPa) adjustable range; and 175-psig (1200-kPa) maximum inlet pressure.
      2) Install compressed-air supply piping from building's compressed-air piping system.

G. Hose-Connection Installation
1. Install hose connections adjacent to standpipes.
2. Install freestanding hose connections for access and minimum passage restriction.
3. Install NPS 1-1/2 (DN 40) hose-connection valves with flow-restricting device.

4. Install NPS 2-1/2 (DN 65) hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40) reducer adapter and flow-restricting device.
5. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Division 10 Section "Fire Extinguisher Cabinets".

H. Hose-Station Installation
1. Install freestanding hose stations for access and minimum passage restriction.
2. Install NPS 1-1/2 (DN 40) hose-station valves with flow-restricting device unless otherwise indicated.
3. Install NPS 2-1/2 (DN 65) hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 (DN 65 by DN 40) reducer adapter and flow-restricting device unless otherwise indicated.
4. Install freestanding hose stations with support or bracket attached to standpipe.
5. Install wall-mounted, rack hose stations in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose. Comply with requirements for cabinets in Division 10 Section "Fire Extinguisher Cabinets".
6. Install hose-reel hose stations on wall with bracket.

I. Monitor Installation
1. Install monitors on standpipe piping.

J. Fire-Department Connection Installation
1. Install wall-type, fire-department connections.
2. Install yard-type, fire-department connections in concrete slab support. Comply with requirements for concrete in Division 03 Section "Cast-in-place Concrete".
   a. Install two **OR** three, **as directed**, protective pipe bollards around **OR** on sides of, **as directed**, each fire-department connection. Comply with requirements for bollards in Division 05 Section "Metal Fabrications".
3. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

K. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors.
2. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set-screw **OR** stamped steel with set-screw or spring clips **OR** stamped steel with spring clips, **as directed**.
   c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set-screw **OR** One piece or split plate, stamped steel with set-screw **OR** Split plate, stamped steel with set-screw, **as directed**.
   d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directed**.
   e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set-screw **OR** stamped steel with spring clips **OR** stamped steel with set-screw or spring clips, **as directe**.
   f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
3. Escutcheons for Existing Piping:
   a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.

b. Insulated Piping: Split plate, stamped steel with concealed or exposed-rivet hinge and spring clips.
c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set-screw, **as directed**.
e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set-screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set-screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set-screw or spring clips, **as directed**.
f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set-screw or spring clips, **as directed**.
g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

L. Sleeve Installation
1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
2. Sleeves are not required for core-drilled holes.
3. Permanent sleeves are not required for holes formed by removable PE sleeves.
4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
5. Install sleeves in new partitions, slabs, and walls as they are built.
6. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements for joint sealants in Division 07 Section "Joint Sealants".
8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals.
9. Seal space outside of sleeves in concrete slabs and walls with grout.
10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
11. Install sleeve materials according to the following applications:
    a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
    b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Galvanized-steel pipe **OR** Stack sleeve fittings, **as directed**.
        1) Extend sleeves 2 inches (50 mm) above finished floor level.
        2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements for flashing in Division 07 Section "Sheet Metal Flashing And Trim".
    c. Sleeves for Piping Passing through Gypsum-Board Partitions:
        1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
        2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.
        3) Exception: Sleeves are not required for water-supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
    d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Galvanized-steel pipe, **as directed**.
    e. Sleeves for Piping Passing through Exterior Concrete Walls:
        1) Galvanized-steel-pipe sleeves for pipes smaller than NPS 6 (DN 150).

2) Cast-iron wall pipe sleeves for pipes NPS 6 (DN 150) and larger.
3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.

f. Sleeves for Piping Passing through Interior Concrete Walls:
1) PVC-pipe **OR** Galvanized-steel-pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
2) Galvanized-steel-sheet sleeves for pipes NPS 6 (DN 150) and larger.

12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestop materials and installations in Division 07 Section "Through-penetration Firestop Systems".

M. Sleeve Seal Installation
1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

N. Identification
1. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 14.
2. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".

O. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
a. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
c. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
d. Energize circuits to electrical equipment and devices.
e. Start and run air compressors.
f. Coordinate with fire-alarm tests. Operate as required.
g. Coordinate with fire-pump tests. Operate as required.
h. Verify that equipment hose threads are same as local fire-department equipment.
3. Fire-suppression standpipe system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

P. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

Q. Piping Schedule
1. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded **OR** grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved, **as directed**, joints.
2. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:
a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.

b. Standard-weight **OR** Schedule 30 or thinwall, **as directed**, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
g. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.
h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
i. Type L (Type B) **OR** Type M (Type B), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.

3. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following:
   a. Standard-weight **OR** Schedule 30, **as directed**, or thinwall, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   f. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   g. Thinwall **OR** Schedule 10, **as directed**, or hybrid black-steel pipe with plain ends; welding fittings; and welded joints.
   h. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   i. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
4. Standard-pressure, wet-type, fire-suppression standpipe piping, NPS 10 and NPS 12 (DN 250 and DN 300), shall be one of the following:
   a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.

f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.

5. High-pressure, wet-type, fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:
   a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   c. Standard-weight or Schedule 30, black-steel pipe with cut-grooved **OR** roll-grooved, **as directed**, ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.
6. High-pressure, wet-type, fire-suppression standpipe piping, NPS 5 (DN 125) and larger, shall be one of the following:
   a. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   c. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   d. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   e. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
   f. Thinwall **OR** Schedule 10, **as directed**, **OR** nonstandard OD, thinwall or hybrid, **as directed**, black-steel pipe with plain ends; welding fittings; and welded joints.
7. Standard-pressure, dry-type, fire-suppression standpipe piping, NPS 4 (DN 100) and smaller, shall be one of the following:
   a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.
   d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.
8. Standard-pressure, dry-type, fire-suppression standpipe piping, NPS 5 and NPS 6 (DN 125 and DN 150), shall be one of the following:
   a. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
   c. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with plain ends; cast- or wrought-copper solder-joint fittings; and brazed joints.

d. Type L (Type B) **OR** Type M (Type C), **as directed**, hard copper tube with roll-grooved ends; copper, grooved-end fittings; grooved-end-tube couplings; and grooved joints.

END OF SECTION 13975

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Task	Specification	Specification Description
13975	01352	No Specification Required

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SECTION 14215 - LIMITED-USE/LIMITED-APPLICATION ELEVATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for limited-use/limited-application elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes limited-use/limited-application (LU/LA) elevators.

C. Definitions
1. Definitions in ASME A17.1 apply to Work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

D. Performance Requirements
1. Rated Load: 1400 lb (635 kg).
2. Rated Speed: 25 to 30 fpm (0.13 to 0.15 m/s).

E. Submittals
1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating coordination with building structure, relationships with other construction, and locations of equipment and signals.
3. Samples: For exposed finishes.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator being provided.
5. Qualification Data: For Installer.
6. Operation and maintenance data.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction, for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

F. Quality Assurance
1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.
   a. Affected peak velocity acceleration (Av) for Project's location is less than 0.10 (Seismic Risk Zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (Seismic Risk Zone 2) **OR** greater than or equal to 0.20 (Seismic Risk Zones 3 and 4), **as directed**.
   b. Project's Seismic Design Category is A **OR** B **OR** C **OR** D, **as directed**.
   c. Elevator's Importance Factor is 1.5 **OR** 1.0, **as directed**.
3. Accessibility Requirements: Comply with Sections 407.4.1 through 407.4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ICC A117.1, **as directed**.

4. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** UBC Standard 7-2 **OR** UL 10B, **as directed**.

G. Delivery, Storage, And Handling
1. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

H. Warranty
1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within one year from date of Substantial Completion.

1.2 PRODUCTS

A. Components
1. General: Provide manufacturer's standard LU/LA elevator. Where components are not otherwise indicated, provide standard components, published by manufacturer as included in standard LU/LA elevators and as required for complete system.
2. Machine Type: Hydraulic, holeless, beside the car; either roped hydraulic or direct-acting hydraulic.
3. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations. Provide the following:
   a. Submersible pump, with submersible squirrel-cage induction motor, **as directed**, suspended inside oil tank from vibration isolation mounts.
   b. Pump motor with solid-state starting **OR** variable-voltage, variable-frequency motor control, **as directed**.
   c. Hydraulic silencer and flexible piping connectors at pump unit.
4. Hydraulic Fluid: Fire-resistant fluid with antioxidant, anticorrosive, antifoaming, and metal-passivating additives. Hydraulic fluid is approved by elevator manufacturer for use with elevator equipment.
5. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.

B. Operation Systems
1. General: Provide manufacturer's standard microprocessor, **as directed**, operation system for single automatic operation **OR** selective collective automatic operation, **as directed**.
2. Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put into service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby, **as directed**. Manual operation causes automatic operation to cease.
3. Battery-Powered Lowering: Provide system that, when power fails, lowers car to the lowest floor, opens car and hoistway door, and shuts down. System includes rechargeable battery and automatic recharging system.
4. Emergency Operation: None required **OR** Phase I emergency recall operation **OR** Phase I emergency recall operation and Phase II emergency in-car operation, **as directed**.

C. Door Reopening Devices

1. Photoelectric Device: Provide photoelectric device that projects light beam across car entrance. Device is capable of sensing objects at 5 and 29 inches (125 and 735 mm) above the floor, **as directed**. Interruption of light beam shall cause doors to stop and reopen.
2. Infrared Array: Provide door-reopening devices with a uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.

D. Finish Materials
1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
5. Stainless-Steel Bars: ASTM A 276, Type 304.
6. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
7. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.
8. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications **OR** Type HGL for flat applications, **as directed**, and Type BKV for panel backing.

E. Elevator Car Enclosures
1. General: Provide steel-framed car enclosures with wall panels, car roof, access doors, power door operators, and ventilation. Provide finished car including materials and finishes specified below.
2. Clear Inside Dimensions:
   a. Inside Width: 36 inches (915 mm) **OR** 42 inches (1065 mm) **OR** 48 inches (1219 mm), **as directed**, from sidewall to sidewall.
   b. Inside Depth: 48 inches (1219 mm) **OR** 54 inches (1370 mm) **OR** 60 inches (1524 mm), **as directed**, from back wall to front wall (return panels).
   c. Inside Height: 84 inches (2134 mm) to underside of ceiling.
3. Materials and Finishes: Provide manufacturer's standards, but not less than the following:
   a. Floor Finish: Specified in a Division 07 **OR** Elevator manufacturer's standard level-loop nylon carpet; color as selected from manufacturer's full range, **as directed**.
   b. Enameled-Steel Wall Panels: Flush construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected from manufacturer's full range.
   c. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet; polished, No. 8 **OR** satin, No. 4, **as directed**, finish.
   d. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to manufacturer's standard core with plastic-laminate panel backing and manufacturer's standard protective edge trim. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
   e. Sills: Extruded aluminum, with grooved surface, 1/4 inch (6.4 mm) thick.
   f. Metal Ceiling: Flush panels, fabricated from cold-rolled steel sheet. Provide panels with factory-applied enamel or powder-coat finish; colors as selected from manufacturer's full range.
   g. Lighting: Not less than two incandescent downlights. Provide battery backup power source with automatic charging, **as directed**.
   h. Handrail: 1-1/2 inches (38 mm) round **OR** 1/2 by 2 inches (13 by 50 mm) rectangular **OR** Manufacturer's standard, **as directed**, polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish, **as directed**, on one side **OR** on both sides **OR** at rear, **as directed**, of car.
4. Car Doors: Manufacturer's standard units complete with track systems, hardware, sills, and accessories.
   a. Operation: Manual **OR** Automatic, **as directed**.
   b. Type: Horizontal sliding **OR** Folding, **as directed**.

c. Clear Opening Width: 32 inches (815 mm) **OR** 36 inches (914 mm), **as directed**.
d. Door Height: 80 inches (2032 mm) **OR** 84 inches (2134 mm), **as directed**.
e. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel or powder-coat finish; colors as selected from manufacturer's full range.
f. Primed-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer for field painting.
g. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning. Polished, No. 8 **OR** Satin, No. 4, **as directed**, finish.
h. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
i. Aluminum Folding Doors: Aluminum extrusions with edges forming full-height hinges connected by stainless-steel rod.

F. Hoistway Entrances
1. General: Provide manufacturer's standard door-and-frame hoistway entrances, same size as car doors, complete with track systems, hardware, sills, and accessories.
a. Operation: Manual **OR** Automatic, **as directed**.
b. Type: Horizontal sliding **OR** Side hinged, **as directed**.
2. Provide frame size and profile to coordinate with hoistway wall construction.
a. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.
3. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
a. Enameled-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
b. Primed-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer for field painting.
c. Stainless-Steel Frames: Formed from stainless-steel sheet; polished, No. 8 **OR** satin, No. 4, **as directed**, finish.
d. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
e. Primed-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied, corrosion-resistant primer for field painting.
f. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet or by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning. Polished, No. 8 **OR** Satin, No. 4, **as directed**, finish.
g. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
h. Sills: Extruded aluminum, with grooved surface, 1/4 inch (6.4 mm) thick.
i. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.
4. Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C).

G. Signal Equipment

1. General: Provide buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
   a. Finish: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish, **as directed**.
2. Car Control Stations: Provide manufacturer's standard car control stations. Mount in side panel adjacent to car door, unless otherwise indicated.
   a. Mark buttons and switches with standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
   b. Provide "No Smoking" sign matching car control station, either integral with car control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.
3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ICC A117.1, **as directed**. On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System indicates when it has been activated and when monitoring station has responded. System provides for two-way communication, by both voice and visual display, together with push buttons. System is contained in cabinet, with identification, instructions for use, and battery backup power supply.
   OR
   Emergency Telephone: Provide telephone cabinet with emergency telephone. On activation, telephone dials preprogrammed number of monitoring station **OR** 911, **as directed**, and identifies elevator location. Telephone provides two-way voice communication.
4. Car Position Indicator: Provide digital-type position indicator in elevator car. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served. Include travel direction arrows if not provided in car control station.
5. Hall Push-Button Stations: Manufacturer's standard wall-mounted units, equipped with buttons for calling elevator and for indicating desired direction of travel where applicable.
6. Hall Lanterns: Manufacturer's standard units with illuminated arrows, but provide single arrow at terminal landings.
7. Hall Annunciator: Provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
8. Emergency Signs: Provide signs matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire the elevators are out of service and exit stairs should be used instead. Provide one sign at each hall push-button station, unless otherwise indicated.

1.3 EXECUTION

A. Installation
1. Install cylinder plumb and accurately located for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.
2. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.
3. Lubricate operating parts of systems as recommended by manufacturers.
4. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Reduce clearances to minimum safe workable dimension at each landing.
5. Leveling Tolerance: 1/4 inch (6 mm), up or down, regardless of load and direction of travel.
6. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.

7. Locate hall lanterns either above or beside hoistway entrance at a minimum of 72 inches (1829 mm) above finished floor unless hall lanterns are built into entrance frames.

B. Field Quality Control
1. Acceptance Testing: On completion of elevator installation and before permitting use of elevator, perform acceptance tests as required and recommended by ASME A17.1 and by authorities having jurisdiction.
2. Advise Owner and authorities having jurisdiction in advance of dates and times tests are to be performed.

C. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate, adjust, and maintain elevator.
2. Check operation of elevator with Owner's personnel present and before date of Substantial Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of elevator with Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14215

SECTION 14240 - HYDRAULIC ELEVATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hydraulic elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes hydraulic passenger and service elevators.

C. Definitions
1. Definitions in ASME A17.1 apply to work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
3. Service Elevator: A passenger elevator that is also used to carry freight.

D. Submittals
1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for the following:
   a. Car enclosures and hoistway entrances.
   b. Operation, control, and signal systems.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment and signals. Include large-scale layout of car control station and standby power operation control panel, **as directed**. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
3. Samples: For exposed finishes of cars, hoistway doors and frames, and signal equipment; 3-inch- (75-mm-) square Samples of sheet materials; and 4-inch (100-mm) lengths of running trim members.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain elevators, including electric traction passenger elevators specified in another Division 14 Section, through one source from a single manufacturer.
   a. Provide major elevator components, including pump-and-tank units, plunger-cylinder assemblies, controllers, signal fixtures, door operators, car frames, cabs, and entrances, manufactured by a single manufacturer.

3. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.
   a. Effective peak velocity acceleration (Av) for Project's location is less than 0.10 (seismic risk zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (seismic risk zone 2) **OR** greater than or equal to 0.20 (seismic risk zones 3 and 4), **as directed**.
   b. Design earthquake spectral response acceleration, short period (Sds) for Project is determined by Project's location and site classification.
   c. Project's seismic design category is A **OR** B **OR** C **OR** D, **as directed**.
   d. Elevator importance factor is 1.5 **OR** 1.0, **as directed**.
4. Accessibility Requirements: Comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** 407 in ICC A117.1, **as directed**.
5. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** UBC Standard 7-2 **OR** UL 10B, **as directed**.

F. Delivery, Storage, And Handling
1. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

G. Coordination
1. Coordinate installation of sleeves, block outs, and items that are embedded in concrete or masonry for elevator equipment. Furnish templates and installation instructions and deliver to Project site in time for installation.
2. Furnish well casing and coordinate delivery with related excavation work.
3. Coordinate sequence of elevator installation with other work to avoid delaying the Work.
4. Coordinate locations and dimensions of other work relating to hydraulic elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; and electrical service, electrical outlets, lights, and switches in pits and machine rooms.

H. Warranty
1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within specified warranty period.
   a. Warranty Period: One year from date of Substantial Completion.

1.2 PRODUCTS

A. Systems And Components
1. General: Provide manufacturer's standard elevator systems. Where components are not otherwise indicated, provide standard components published by manufacturer as included in standard preengineered elevator systems and as required for complete system.
2. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations. Provide the following, **as directed**:
   a. Pump, with fan-cooled squirrel-cage induction motor, mounted on oil tank with vibration isolation mounts. Enclose pump in prime-painted steel enclosure lined with 1-inch- (25-mm-) thick, glass-fiber insulation board.
   b. Submersible pump, with submersible squirrel-cage induction motor, suspended inside oil tank from vibration isolation mounts.
   c. Provide motor with wye-delta **OR** solid-state, **as directed**, starting.
   d. Provide variable-voltage variable-frequency motor control.

3. Hydraulic Silencers: Provide hydraulic silencer containing pulsation-absorbing material in a blowout-proof housing at pump unit.
4. Piping: Provide size, type, and weight piping recommended by manufacturer, and provide flexible connectors to minimize sound and vibration transmissions from power unit.
   a. Provide dielectric couplings at cylinder units.
   b. Casing for Underground Piping: PVC pipe complying with ASTM D 1785, joined with PVC fittings complying with ASTM D 2466 and solvent cement complying with ASTM D 2564.
5. Hydraulic Fluid: Elevator manufacturer's standard fire-resistant, **as directed**, fluid with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.
   OR
   Hydraulic Fluid: Nontoxic, readily biodegradable, fire-resistant, **as directed**, fluid made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives. Hydraulic fluid is approved by elevator manufacturer for use with elevator equipment.
6. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.
7. Protective Cylinder Casing: PVC or HDPE pipe casing complying with ASME A17.1, of sufficient size to provide not less than 1-inch (25-mm) clearance from cylinder and extending above pit floor. Provide means to monitor casing effectiveness to comply with ASME A17.1.
8. Corrosion Protective Filler: A nontoxic, petroleum-based gel formulated for filling the space between hydraulic cylinder and protective casing. Filler is electrically nonconductive, displaces or absorbs water, and gels or solidifies at temperatures below 60 deg F (16 deg C).
9. Car Frame and Platform: Welded steel units.
10. Guides: Provide either roller guides or sliding guides at top and bottom of car and counterweight frames. If sliding guides are used, provide guide-rail lubricators or polymer-coated, nonlubricated guides.

B. Operation Systems
1. General: Provide manufacturer's standard microprocessor operation system for each elevator **OR** for each group of elevators, **as directed**, as required to provide type of operation system indicated.
2. Auxiliary **OR** Single-Car Auxiliary, **as directed**, Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:
   a. Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.
      OR
      Standby-Powered Lowering: On activation of standby power, if car is at a floor it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to a preselected floor, opens its doors, and shuts down. If car is below the preselected floor, it is lowered to the next lower floor, opens its doors, and shuts down.
      OR
      Standby-Powered Lowering: On activation of standby power, car is lowered to the lowest floor, opens its doors, and shuts down.
      OR
      Battery-Powered Lowering: If power fails and car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to a preselected floor, opens its doors, and shuts down. If car is below the preselected floor, it is lowered to the next lower floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
      OR

Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.

b. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.

c. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.

3. Group Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators and elevator groups where indicated:

a. Standby Power Operation: On activation of standby power, cars are returned to a designated floor and parked with doors open. Only one car is moved upward at a time, with priority given to loaded cars. If a car cannot be returned after two attempts, it is removed from the system. When all cars have been returned or removed from the system, one car is automatically placed in service. If car selected for service cannot operate within 60 seconds, the system removes car from service and places another car in service. Cars can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.

OR

Standby Power Operation: On activation of standby power, cars are returned to lowest floor and parked with doors open. If a car cannot be returned, it is removed from the system. One car is selected for service on standby power by a switch located at main lobby **OR** fire command station, **as directed**.

OR

Standby-Powered Lowering: On activation of standby power, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered to a preselected floor, open their doors, and shut down. Cars that are below the preselected floor are lowered to the next lower floor, open their doors, and shut down.

OR

Standby-Powered Lowering: On activation of standby power, cars are lowered to the lowest floor, open their doors, and shut down.

OR

Battery-Powered Lowering: If power fails, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered to a preselected floor, open their doors, and shut down. Cars that are below the preselected floor are lowered to the next lower floor, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.

OR

Battery-Powered Lowering: When power fails, cars are lowered to the lowest floor, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.

b. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.

c. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.

d. Emergency Hospital **OR** Priority, **as directed**, Service: Service is initiated by a keyswitch **OR** card reader **OR** remote switch, **as directed**, at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. On arriving at the floor, elevator opens its doors and parks and a lighted sign directs passengers to exit elevator, **as directed**. Car is placed in operation by selecting a floor and pressing door close button or by operating keyswitch to put car in independent service. After responding to floor selected or being removed from independent service, car is

returned to group operation. If car is not placed in operation within a preset time after being called, it is returned to group operation.

e. Independent Service: Keyswitch in car control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from keyswitch when car is in independent service. When in independent service, doors close only in response to door close button.

f. Loaded-Car Bypass: When car load exceeds 80 percent of rated capacity, car will respond only to car calls, not to hall calls.

4. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.

a. Card-Reader Operation: System uses card readers at car control stations **OR** hall push-button stations, **as directed**, to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car **OR** Provide stripe-swipe card reader integral with each car control station, **as directed**.

1) Security access system equipment is specified in Division 13 Section "Security Access".

OR

Security access system equipment is not in the Contract.

b. Keyswitch Operation: Push buttons are activated and deactivated by security keyswitches at car control stations **OR** hall push-button stations, **as directed**. Key is removable only in deactivated position **OR** in either position, **as directed**.

c. Keypad Operation: Allows each landing to be restricted or unrestricted. When a restricted landing button is pressed, a "Restricted Floor" lamp lights and remains lit until landing access code has been entered into a keypad or predetermined time period has elapsed. Car calls for restricted landings do not register until landing access code is entered into keypad within predetermined time period after landing button is pressed.

1) Access codes are programmed at each car operating panel using a security keyswitch. Keypad operation can be activated and deactivated by security keyswitch at main landing.

d. Car-to-Lobby Feature: Feature, activated by keyswitch at main lobby, that causes car **OR** all cars in a group, **as directed**, to return immediately to lobby and open doors for inspection. On deactivation by keyswitch, calls registered before keyswitch activation are completed and normal operation is resumed.

C. Door Reopening Devices

1. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.

2. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

D. Finish Materials

1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.

2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.

3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.

4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.

a. Textured Stainless-Steel Sheet: Product with coined **OR** embossed, **as directed**, texture rolled into exposed surface.

1) Metal surface is satin polished **OR** satin relieved **OR** titanium nitride colored **OR** oxide colored **OR** satin polished and titanium nitride colored **OR** satin relieved and

titanium nitride colored **OR** satin polished and oxide colored **OR** satin relieved and oxide colored **OR** color coated and satin relieved **OR** color coated and bright relieved, **as directed**, after rolling.

5. Stainless-Steel Bars: ASTM A 276, Type 304.
6. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
7. Bronze Plate and Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal).
8. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
9. Bronze Tubing: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
10. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.
11. Nickel Silver Extrusions: ASTM B 151/B 151M, Alloy UNS No. C74500 or No. C77600.
12. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications **OR** Type HGL for flat applications, **as directed**, Type HGP for postformed applications and Type BKV for panel backing.

E. Car Enclosures

1. General: Provide enameled-steel car enclosures to receive removable **OR** steel-framed car enclosures with nonremovable, **as directed**, wall panels, with car **OR** removable car, **as directed**, roof, access doors, power door operators, and ventilation.
   a. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.
   b. Provide finished car including materials and finishes specified below.
2. Materials and Finishes: Provide manufacturer's standards, but not less than the following:
   a. Subfloor: Underlayment grade, exterior plywood, 5/8-inch (16-mm) nominal thickness.
   b. Floor Finish: Specified in a Division 07 **OR** Elevator manufacturer's standard level-loop nylon carpet; color as selected from manufacturer's full range, **as directed**.
   c. Enameled-Steel Wall Panels: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
   d. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
   e. Bronze Wall Panels: Flush, hollow-metal construction; fabricated from bronze sheet.
   f. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard **OR** manufacturer's standard honeycomb core, **as directed**, with plastic-laminate panel backing and, **as directed**, manufacturer's standard protective edge trim. Panels have a flame-spread index of 25 **OR** 75, **as directed**, or less, when tested according to ASTM E 84. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
   g. Fabricate car with recesses and cutouts for signal equipment.
   h. Fabricate car door frame integrally with front wall of car.
   i. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
   j. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
   k. Bronze Doors: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
   l. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching return panels, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.

m. Sight Guards: Provide sight guards on car doors.
n. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
o. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
p. Metal **OR** Metallic-Finish, Plastic-Laminate, **as directed**, Ceiling: Flush panels, with incandescent downlights in the center of **OR** four low-voltage downlights in, **as directed**, each panel. Align ceiling panel joints with joints between wall panels, **as directed**.
q. Handrails: Manufacturer's standard handrails, of shape, metal, and finish indicated.

F. Hoistway Entrances
1. General: Provide manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Provide frame size and profile to coordinate with hoistway wall construction.
a. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.
2. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
a. Enameled-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
b. Steel Subframes: Formed from cold-rolled or hot-rolled steel sheet with factory-applied enamel finish or corrosion-inhibiting primer. Fabricate to receive applied finish as indicated.
c. Stainless-Steel Frames: Formed from stainless-steel sheet.
d. Bronze Frames: Formed from cold-rolled or hot-rolled steel sheet, with enamel finish, and with formed-bronze sheet laminated to steel frames using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
e. Enameled-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
f. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
g. Bronze Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
h. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching door frames, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
i. Sight Guards: Provide sight guards on doors matching door edges.
j. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
k. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.

G. Signal Equipment
1. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
2. Car Control Stations: Provide manufacturer's standard recessed **OR** semirecessed, **as directed**, car control stations. Mount in return panel adjacent to car door, unless otherwise indicated.
OR
Swing-Return Car Control Stations: Provide car control stations mounted on rear of hinged return panel adjacent to car door and with buttons, switches, controls, and indicator lights projecting through return panel but substantially flush with face of return panel.

a. Mark buttons and switches with standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
b. Provide "No Smoking" sign matching car control station, either integral with car control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.

3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)." On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
4. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet **OR** telephone jack, **as directed**, in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System"
5. Car Position Indicator: Provide illuminated, **as directed**, digital-type car position indicator, located above car door or above car control station. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served.
   a. Include travel direction arrows if not provided in car control station.
6. Hall Push-Button Stations: Provide one hall push-button station at each landing for each single elevator or group of elevators, but not less than one station for each four elevators in a group, **as directed**.
   OR
   Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.
   a. Provide manufacturer's standard wall-mounted units.
   b. Provide units with flat faceplate for mounting with body of unit recessed in wall.
   c. Equip units with buttons for calling elevator and for indicating desired direction of travel.
   d. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".
7. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following, **as directed**:
   a. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
   b. Units with flat faceplate for mounting with body of unit recessed in wall and with illuminated elements projecting from faceplate for ease of angular viewing.
   c. Units mounted in both jambs of entrance frame for each elevator, **as directed**.
   d. Units mounted in both car door jambs; may be used only for single elevators or for two-car groups, **as directed**.
8. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
   a. At manufacturer's option, audible signals may be placed on car **OR** each car, **as directed**.
9. Hall Position Indicators: Provide illuminated, **as directed**, digital-display-type position indicators, located above each, **as directed**, hoistway entrance at ground floor. Provide units with flat faceplate for mounting and with body of unit recessed in wall.
   a. Integrate ground-floor hall lanterns with hall position indicators.
10. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open, **as directed**.
    OR
    Fire Command Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal

that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.

11. Corridor Call Station Pictograph Signs: Provide signs matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station, unless otherwise indicated.

H. Elevators

1. Elevator Description:
   a. Group Number: Insert a different number for each group of elevators that share a group operation system, as directed by the Owner.
   b. Elevator Number(s): Insert elevator number(s) as shown on Drawings, as directed by the Owner.
   c. Service Elevator Number(s): Insert elevator number(s) as shown on Drawings, as directed by the Owner.
   d. Type: Under-the-car single cylinder.
      OR
      Type: Holeless, beside-the-car, single-acting, single **OR** dual, **as directed**, cylinder.
      OR
      Type: Holeless, beside-the-car, telescoping, single **OR** dual, **as directed**, cylinder.
      OR
      Type: Holeless, beside-the-car, roped hydraulic, single **OR** dual, **as directed**, cylinder.
   e. Rated Load: 2000 lb (908 kg) **OR** 2100 lb (953 kg) **OR** 2500 lb (1135 kg) **OR** 3000 lb (1362 kg) **OR** 3500 lb (1589 kg) **OR** 4000 lb (1816 kg) **OR** 4500 lb (2043 kg) **OR** 5000 lb (2270 kg), **as directed**.
   f. Freight Loading Class for Service Elevators: Class A.
   g. Rated Speed: 75 or 80 fpm (0.38 or 0.41 m/s) **OR** 100 fpm (0.51 m/s) **OR** 125 fpm (0.64 m/s) **OR** 150 fpm (0.76 m/s) **OR** 175 fpm (0.89 m/s) **OR** 200 fpm (1.0 m/s), **as directed**.
   h. Operation System: Single automatic **OR** Selective collective automatic **OR** Group automatic, **as directed**, operation.
   i. Auxiliary Operations:
      1) Standby power operation.
      2) Standby-powered lowering.
      3) Battery-powered lowering.
      4) Automatic dispatching of loaded car.
      5) Nuisance call cancel.
      6) Emergency hospital **OR** Priority, **as directed**, service at designated floors **OR** all floors, **as directed**.
      7) Independent service for service elevator **OR** all cars in group, **as directed**.
      8) Loaded-car bypass.
   j. Security Features: Card-reader operation **OR** Keyswitch operation **OR** Keypad operation **OR** Car-to-lobby feature, **as directed**.
   k. Dual Car Control Stations: Provide two car control stations in each elevator, **as directed**; equip only one with required keyswitches, if any.
   l. Car Enclosures:
      1) Inside Width: 64 inches (1626 mm) **OR** 68 inches (1727 mm) **OR** 80 inches (2032 mm) **OR** 92 inches (2337 mm), **as directed**, from side wall to side wall.
      2) Inside Depth: 51 inches (1295 mm) **OR** 53 inches (1346 mm) **OR** 57 inches (1448 mm) **OR** 65 inches (1651 mm) **OR** 87-1/2 inches (2222 mm) **OR** 90 inches (2286 mm) **OR** 93 inches (2362 mm) **OR** 93-1/2 inches (2375 mm) **OR** 96 inches (2438 mm) **OR** 101 inches (2565 mm) **OR** 102 inches (2591 mm), **as directed**, from back wall to front wall (return panels).

3) Inside Height: 88 inches (2235 mm) **OR** 92 inches (2337 mm) **OR** 94 inches (2388 mm) **OR** 100 inches (2540 mm) **OR** 104 inches (2642 mm) **OR** 108 inches (2743 mm) **OR** 112 inches (2845 mm), **as directed**, to underside of ceiling.
4) Front Walls (Return Panels): Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**, with integral car door frames.
5) Car Fixtures: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
6) Side and Rear Wall Panels: Enameled steel **OR** Plastic laminate **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel, **as directed**.
7) Reveals: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
8) Door Faces (Interior): Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
9) Door Sills: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
10) Ceiling: Luminous ceiling **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Reflective metallic-finish, plastic-laminate, stainless steel **OR** Reflective metallic-finish, plastic-laminate, bronze, **as directed**.
11) Handrails: 1-1/2 inches (38 mm) round **OR** 1/2 by 2 inches (13 by 50 mm) rectangular, **as directed**, mirror-polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** mirror-polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**, at sides **OR** sides and rear, **as directed**, of car.
12) Floor: Manufacturer's standard carpet.
OR
Floor prepared to receive carpet (specified in Division 09 Section "Carpet").
OR
Floor prepared to receive resilient tile (specified in Division 09 Section "Resilient Floor Tile").
OR
Floor prepared to receive sheet vinyl (specified in Division 09 Section "Resilient Sheet Flooring").
OR
Floor recessed and prepared to receive dimension stone tile (specified in Division 09 Section "Dimension Stone Tile") **OR** ceramic tile (specified in Division 09 Section "Ceramic Tile"), **as directed**.
OR
Floor Thickness, Including Setting Materials: Thickness above plywood subfloor, shall be as directed by the Owner.

m. Hoistway Entrances:
1) Width: 36 inches (914 mm) **OR** 42 inches (1067 mm) **OR** 48 inches (1219 mm) **OR** 54 inches (1372 mm), **as directed**.
2) Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm), **as directed**.
3) Type: Single-speed side sliding **OR** Two-speed side sliding **OR** Single-speed center opening **OR** Two-speed center opening, **as directed**.
4) Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C), **as directeed**.
5) Frames at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.

6) Frames at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
7) Doors and Transoms at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
8) Doors and Transoms at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
9) Sills at First Floor **OR** at Basement Floors, **as directed**: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
10) Sills at Other Floors: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.

n. Hall Fixtures at First Floor **OR** at Basement Floors, **as directed**: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.

o. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.

p. Additional Requirements:
1) Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**.
2) Provide blanket hooks in all cars, **as directed**, and one **OR** two, **as directed**, complete set(s) of full-height protective blankets.

1.3 EXECUTION

A. Examination
1. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Verify critical dimensions and examine supporting structure and other conditions under which elevator work is to be installed.
   a. For the record, prepare a written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.
   b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation
1. Excavation for Cylinder: Drill well hole in each, **as directed**, elevator pit to accommodate installation of cylinder; comply with applicable requirements in Division 02 Section "Earthwork".
2. Provide waterproof well casing as necessary to retain walls of well hole.
3. Install cylinder in protective casing within well hole. Before installing protective casing, remove water and debris from well hole and provide permanent waterproof seal at bottom of well casing, **as directed**.
   a. Fill void space between protective casing and cylinder with corrosion protective filler.
   b. Align cylinders and fill space around protective casing with fine sand.
4. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between well **OR** protective, **as directed**, casing and pit floor with 4 inches (100 mm) of nonshrink, nonmetallic grout.
5. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.

6. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.
7. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.
8. Install piping above the floor, where possible. Where not possible, install underground piping in Schedule 40 PVC pipe casing assembled with solvent-cemented fittings.
   OR
   Install piping above the floor, where possible. Where not possible, cover underground piping with permanent protective wrapping before backfilling.
9. Lubricate operating parts of systems as recommended by manufacturers.
10. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
11. Leveling Tolerance: 1/4 inch (6 mm), up or down, regardless of load and direction of travel.
12. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.
13. Locate hall signal equipment for elevators as follows, unless otherwise indicated:
    a. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.
    b. Place hall lanterns either above or beside each hoistway entrance.
    c. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

C. Field Quality Control
1. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.
2. Advise Owner and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.

D. Protection
1. Temporary Use: Limit temporary use for construction purposes to one elevator, **as directed**. Comply with the following requirements for each, **as directed**, elevator used for construction purposes:
   a. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
   b. Provide strippable protective film on entrance and car doors and frames.
   c. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
   d. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
   e. Do not load elevators beyond their rated weight capacity.
   f. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
   g. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

E. Demonstration
1. Train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).

2. Check operation of each, **as directed**, elevator with Owner's personnel present and before date of Substantial Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of each, **as directed**, elevator with Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14240

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SECTION 14240a - HYDRAULIC FREIGHT ELEVATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hydraulic freight elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes hydraulic freight elevators.

C. Definitions
1. Definitions in ASME A17.1 apply to work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.

D. Submittals
1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment and signals. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
3. Samples for Initial Selection: For finishes involving color selection.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain freight elevators, including electric traction freight elevators specified in another Division 14 Section, through one source from a single manufacturer.
   a. Provide major elevator components, including pump-and-tank units, plunger-cylinder assemblies, controllers, signal fixtures, door operators, car frames, cabs, and entrances, manufactured by a single manufacturer.
3. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.
   a. Effective peak velocity acceleration (Av) for Project's location is less than 0.10 (seismic risk zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (seismic risk zone 2) **OR** greater than or equal to 0.20 (seismic risk zones 3 and 4), **as directed**.
   b. Design earthquake spectral response acceleration, short period (Sds) for Project is determined by Project's location and site classification.

c. Project's seismic design category is A **OR** B **OR** C **OR** D, **as directed**.
d. Elevator importance factor is 1.5 **OR** 1.0, **as directed**.

4. Accessibility Requirements: Comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** 407 in ICC A117.1, **as directed**.
5. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** UBC Standard 7-2 **OR** UL 10B, **as directed**.

F. Delivery, Storage, And Handling
1. Deliver, store, and handle materials, components and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

G. Coordination
1. Coordinate installation of sleeves, block outs, and items that are embedded in concrete or masonry for elevator equipment. Furnish templates and installation instructions and deliver to Project site in time for installation.
2. Furnish well casing and coordinate delivery with related excavation work.
3. Coordinate sequence of freight elevator installation with other work to avoid delaying the Work.
4. Coordinate locations and dimensions of other work relating to hydraulic freight elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; and electrical service, electrical outlets, lights, and switches in pits and machine rooms.

H. Warranty
1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within specified warranty period.
a. Warranty Period: One year from date of Substantial Completion.

1.2 PRODUCTS

A. Systems And Components
1. General: Provide manufacturer's standard freight elevator systems. Where components are not otherwise indicated, provide standard components published by manufacturer as included in standard preengineered freight elevator systems and as required for complete system.
2. Pump Units: Positive-displacement type with a maximum of 10 percent variation between no load and full load and with minimum pulsations. Provide either of the following:
a. Pump, with fan-cooled squirrel-cage induction motor, mounted on oil tank with vibration isolation mounts. Enclose pump in prime-painted steel enclosure lined with 1-inch- (25-mm-) thick, glass-fiber insulation board.
b. Submersible pump, with submersible squirrel-cage induction motor, suspended inside oil tank from vibration isolation mounts.
c. Provide motor with wye-delta or solid-state starting.
3. Hydraulic Silencers: Provide hydraulic silencer containing pulsation-absorbing material in a blowout-proof housing at pump unit.
4. Piping: Provide size, type, and weight piping recommended by manufacturer, and provide flexible connectors to minimize sound and vibration transmissions from power unit.
a. Provide dielectric couplings at cylinder units.
b. Casing for Underground Piping: PVC pipe complying with ASTM D 1785, joined with PVC fittings complying with ASTM D 2466 and solvent cement complying with ASTM D 2564.

5. Hydraulic Fluid: Elevator manufacturer's standard fluid **OR** fire-resistant fluid, **as directed**, with additives as needed to prevent oxidation of fluid, corrosion of cylinder and other components, and other adverse effects.
   OR
   Hydraulic Fluid: Nontoxic, readily biodegradable, fluid **OR** fire-resistant fluid, **as directed**, made from vegetable oil with antioxidant, anticorrosive, antifoaming, and metal-passivating additives. Hydraulic fluid is approved by elevator manufacturer for use with elevator equipment.
6. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.
7. Protective Cylinder Casing: PVC or HDPE pipe casing complying with ASME A17.1, of sufficient size to provide not less than 1-inch (25-mm) clearance from cylinder and extending above pit floor. Provide means to monitor casing effectiveness to comply with ASME A17.1.
8. Corrosion Protective Filler: A nontoxic, petroleum-based gel formulated for filling the space between hydraulic cylinder and protective casing. Filler is electrically nonconductive, displaces or absorbs water, and gels or solidifies at temperatures below 60 deg F (16 deg C).
9. Car Frame and Platform: Welded steel units.
   a. Provide special heavy-duty units where indicated for power truck loading, designed to withstand impacts and wheel loadings indicated.
10. Guides: Provide either roller guides or sliding guides at top and bottom of car and counterweight frames. If sliding guides are used, provide guide-rail lubricators or polymer-coated, nonlubricated guides.

B. Operation Systems
1. General: Provide manufacturer's standard microprocessor operation system for each elevator **OR** for each group of elevators, **as directed**, as required to provide type of operation system indicated.
2. Battery-Powered Lowering: When power fails, car is lowered to the lowest floor, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
3. Load-Weighing Device: When car load exceeds 80 percent of rated capacity, a signal light is lit in the car control station; when car load exceeds rated capacity, car will not respond to car or hall calls.
4. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.
   a. Card-Reader Operation: System uses card readers at car control stations **OR** hall push-button stations, **as directed**, to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car **OR** Provide stripe-swipe card reader integral with each car control station, **as directed**.
      1) Security access system equipment is specified in Division 13 Section "Security Access".
         OR
         Security access system equipment is not in the Contract.

      OR
      Keyswitch Operation: Push buttons are activated and deactivated by security keyswitches at car control stations **OR** hall push-button stations, **as directed**. Key is removable only in deactivated position **OR** in either position, **as directed**.

C. Door Reopening Devices
1. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.

D. Finish Materials

1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
4. Metallic-Coated Steel Sheet: ASTM A 653/A 653M, commercial steel, with G60 (Z180) zinc coating (galvanized) or A60 (ZF180) zinc-iron-alloy coating (galvannealed).
5. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
   a. Textured Stainless-Steel Sheet: Product with coined **OR** embossed, **as directed**, texture rolled into exposed surface.
6. Stainless-Steel Bars: ASTM A 276, Type 304.
7. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
8. Rolled Steel Floor Plate: ASTM A 786/A 786M.
9. Rolled Stainless-Steel Floor Plate: ASTM A 793.
10. Aluminum-Alloy Rolled Tread Plate: ASTM B 632/B 632M, Pattern 1, Alloy 6061-T6.

E. Car Enclosures
1. General: Provide car enclosures as indicated, including ventilation, lighting, finishes, access doors, thresholds, trim, and accessories. Fabricate with recesses and cutouts for signal equipment.
   a. Provide power door operators with linkages for hoistway door operation.
   b. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.
2. Materials and Fabrication: Provide manufacturer's standard, flush panel, welded construction made from metal sheet, of metal indicated, not less than 0.067 inch (1.7 mm) and reinforced at 16-inch (406-mm) maximum spacing.
   a. Provide perforated panels for ceiling and for walls above 72 inches (1829 mm) from car floor unless required to be solid by ASME A17.1.

F. Hoistway Entrances
1. General: Structural-steel frames and sills for hoistway entrances are specified in Division 05 Section(s) "Structural Steel" OR "Metal Fabrications", **as directed**. Unless otherwise indicated, provide hoistway entrance doors of type indicated below, with truckable sill bars and resilient safety meeting-rail gaskets.
   a. Equip for power operation by means of coordinated linkage with power-operated car door.
   b. Where gypsum board wall construction is indicated, provide fire-resistance-rated, hollow-metal, door-and-frame hoistway entrances. Provide self-supporting frames with reinforced head sections.
2. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
   a. Metal Door Panels: Constructed of metal sheets, flush on room side, welded and reinforced in steel framing with vertical reinforcing spaced not more than 24 inches (610 mm) o.c. Fabricate panel faces from metal sheet, of metal indicated, not less than 0.097 inch (2.5 mm) thick.

G. Signal Equipment
1. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements of acrylic or other permanent, nonyellowing translucent plastic.
2. Car Control Stations: Provide manufacturer's standard car control station. Mount adjacent to car door, unless otherwise indicated.
   a. Mark buttons and switches with manufacturer's standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
   b. Mount controls at heights complying with the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** ICC A117.1, **as directed**.

3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Building and Facilities (ADAAG)." On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
4. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet **OR** telephone jack, **as directed**, in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".
5. Car Position Indicator: Provide illuminated digital-type car position indicator, located above car door or above car control station.
6. Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.
   a. Provide single-button stations with position **OR** "In-Use", **as directed**, indicator.

H. Elevators
1. Elevator No(s).: <**Insert elevator number(s) as shown on Drawings.**>
   a. Type: Under-the-car single or dual cylinder.
      OR
      Type: Holeless, beside-the-car, single-acting, single **OR** dual, **as directed**, cylinder.
      OR
      Type: Holeless, beside-the-car, telescoping, single **OR** dual, **as directed**, cylinder.
      OR
      Type: Holeless, beside-the-car, roped hydraulic, single **OR** dual, **as directed**, cylinder.
   b. Rated Load: 2000 lb (908 kg) **OR** 2500 lb (1135 kg) **OR** 3000 lb (1362 kg) **OR** 4000 lb (1816 kg) **OR** 5000 lb (2270 kg) **OR** 6000 lb (2720 kg) **OR** 8000 lb (3632 kg) **OR** 10 000 lb (4540 kg), **as directed**.
   c. Freight Loading Class: Class A **OR** B **OR** C1 **OR** C2 **OR** C3, **as directed**.
   d. Rated Speed (Up): 50 fpm (0.25 m/s) **OR** 75 or 80 fpm (0.38 or 0.41 m/s) **OR** 100 fpm (0.51 m/s), **as directed**.
   e. Operational Speed (Down): Approximately 30 percent more than **OR** Same as, **as drected**, rated speed (up).
   f. Operation System: Single automatic **OR** Car-switch automatic floor-stop **OR** Selective collective automatic, **as directed**, operation.
   g. Auxiliary Operations: Battery-powered lowering **OR** Card-reader operation **OR** Keyswitch operation **OR** Load-weighing device, **as directed**.
   h. Auxiliary Car Control Station: Provide additional car control station mounted on side of car at height to facilitate operation by forklift-truck operator without leaving truck.
   i. Car Enclosures:
      1) Platform Width: 60 inches (1524 mm) **OR** 64 inches (1626 mm) **OR** 66 inches (1676 mm) **OR** 76 inches (1930 mm) **OR** 78 inches (1981 mm) **OR** 88 inches (2235 mm) **OR** 100 inches (2540 mm) **OR** 102 inches (2591 mm) **OR** 124 inches (3150 mm) **OR** 126 inches (3200 mm), **as directed**.
      2) Platform Depth: 72 inches (1829 mm) **OR** 84 inches (2134 mm) **OR** 96 inches (2438 mm) **OR** 120 inches (3048 mm) **OR** 144 inches (3658 mm) **OR** 168 inches (4267 mm), **as directed**.
      3) Ceiling Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm) **OR** 108 inches (2743 mm), **as directed**.
      4) Walls and Ceiling: Prime-painted steel **OR** Prime-painted, metallic-coated steel **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel, **as directed**.
      5) Car Fixtures: Satin stainless steel, No. 4 finish.
      6) Floor: Rolled steel floor plate **OR** Aluminum-alloy rolled tread plate **OR** Rolled stainless-steel floor plate, **as directed**.

7) Car Gate Type: Vertical biparting **OR** Single-speed vertical lift **OR** Two-speed vertical lift, **as directed**.
8) Car Gate Operation: Manual **OR** Power operated, **as directed**.
9) Car Gate Material: Prime-painted steel **OR** Satin stainless steel, No. 4 finish, **as directed**.
10) Car Sill: Steel angle.
11) Lighting: One **OR** Two **OR** Three, **as directed**, 48-inch (1219-mm), suspended, **OR** surface-mounted, **as directed**, 2-tube fluorescent light fixture(s) with white reflectors **OR** wire lamp guards, **as directed**.
OR
Lighting: One **OR** Two, **as directed**, 48-inch (1219-mm), recessed, 2 **OR** 3, **as directed**,-tube fluorescent light fixture(s) with UV stabilized acrylic diffusers not less than 0.125 inch (3.2 mm) thick.

j. Hoistway Entrances:
1) Width: 56 inches (1422 mm) **OR** 60 inches (1524 mm) **OR** 62 inches (1575 mm) **OR** 72 inches (1829 mm) **OR** 96 inches (2438 mm) **OR** 98 inches (2489 mm) **OR** 120 inches (3048 mm) **OR** 122 inches (3099 mm), **as directed**.
2) Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm), **as directed**.
3) Door Type: Vertical biparting **OR** Single-speed vertical lift **OR** Two-speed vertical lift, **as directed**.
4) Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C), **as directed**.
5) Door Operation: Manual **OR** Power operated, **as directed**.
6) Door Material: Prime-painted steel **OR** Satin stainless steel, No. 4 finish, **as directed**.
7) Door Frame Material: Prime-painted steel **OR** Satin stainless steel, No. 4 finish, **as directed**.
8) Door frames and sills are specified in Division 05 Section(s) "Structural Steel" OR "Metal Fabrications", **as directed**.

k. Hall Fixtures: Satin stainless steel, No. 4 finish.

l. Auxiliary Hall Stations: Provide additional pendant-mounted, hall push-button stations where indicated mounted at height to facilitate operation by forklift-truck operator without leaving truck.

m. Additional Requirements:
1) Provide door reopening device.

1.3 EXECUTION

A. Examination
1. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Verify critical dimensions and examine supporting structure and other conditions under which elevator work is to be installed.
a. For the record, prepare a written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.
b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation
1. Excavation for Cylinder: Drill well hole in each elevator pit to accommodate installation of cylinder; comply with applicable requirements in Division 02 Section "Earthwork".
2. Provide waterproof well casing as necessary to retain walls of well hole.
3. Install cylinder in protective casing within well hole. Before installing protective casing, remove water and debris from well hole and provide permanent waterproof seal at bottom of well casing.
a. Fill void space between protective casing and cylinder with corrosion-protective filler.

b. Align cylinders and fill space around protective casing with fine sand.

4. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor. Seal between well **OR** protective, **as directed**, casing and pit floor with 4 inches (100 mm) of nonshrink, nonmetallic grout.
5. Install cylinder plumb and accurately centered for elevator car position and travel. Anchor securely in place, supported at pit floor and braced at intervals as needed to maintain alignment. Anchor cylinder guides at spacing needed to maintain alignment and avoid overstressing guides.
6. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.
7. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to effectively prevent transmission of vibrations to structure and thereby eliminate sources of structure-borne noise from elevator system.
8. Install piping above the floor, where possible. Where not possible, install underground piping in Schedule 40 PVC pipe casing assembled with solvent-cemented fittings.
   OR
   Install piping above the floor, where possible. Where not possible, cover underground piping with permanent protective wrapping before backfilling.
9. Lubricate operating parts of systems as recommended by manufacturers.
10. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay installation of sills and frames until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.

C. Field Quality Control

1. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.
2. Advise Owner and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.

D. Protection

1. Temporary Use: Limit temporary use for construction purposes to one elevator, **as directed**. Comply with the following requirements for each, **as directed**, elevator used for construction purposes:
   a. Provide protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
   b. Do not load elevators beyond their rated weight capacity.
   c. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
   d. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

E. Demonstration

1. Train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).
2. Check operation of each elevator with Owner's personnel present and before date of Substantial Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of each elevator with Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14240a

SECTION 14290 - ELECTRIC TRACTION ELEVATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for electric traction elevators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes electric traction passenger and service elevators.

C. Definitions
1. Definitions in ASME A17.1 apply to work of this Section.
2. Defective Elevator Work: Operation or control system failure, including excessive malfunctions; performances below specified ratings; excessive wear; unusual deterioration or aging of materials or finishes; unsafe conditions; need for excessive maintenance; abnormal noise or vibration; and similar unusual, unexpected, and unsatisfactory conditions.
3. Service Elevator: A passenger elevator that is also used to carry freight.

D. Submittals
1. Product Data: Include capacities, sizes, performances, operations, safety features, finishes, and similar information. Include product data for the following:
   a. Car enclosures and hoistway entrances.
   b. Operation, control, and signal systems.
2. Shop Drawings: Show plans, elevations, sections, and large-scale details indicating service at each landing, machine room layout, coordination with building structure, relationships with other construction, and locations of equipment and signals. Include large-scale layout of car control station and standby power operation control panel, **as directed**. Indicate variations from specified requirements, maximum dynamic and static loads imposed on building structure at points of support, and maximum and average power demands.
3. Samples: For exposed finishes of cars, hoistway doors and frames, and signal equipment; 3-inch- (75-mm-) square Samples of sheet materials; and 4-inch (100-mm) lengths of running trim members.
4. Manufacturer Certificates: Signed by elevator manufacturer certifying that hoistway, pit, and machine room layout and dimensions, as shown on Drawings, and electrical service, as shown and specified, are adequate for elevator system being provided.
5. Qualification Data: For Installer.
6. Operation and Maintenance Data: For elevators to include in emergency, operation, and maintenance manuals.
7. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted elevator use.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Installer Qualifications: Elevator manufacturer or manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Source Limitations: Obtain elevators, including hydraulic passenger elevators specified in another Division 14 Section, through one source from a single manufacturer.
   a. Provide major elevator components, including driving machines, controllers, signal fixtures, door operators, car frames, cabs, and entrances, manufactured by a single manufacturer.
3. Regulatory Requirements: Comply with ASME A17.1 and elevator design requirements for earthquake loads in ASCE 7.

a. Effective peak velocity acceleration (Av) for Project's location is less than 0.10 (seismic risk zones 0 and 1) **OR** greater than or equal to 0.10, but less than 0.20 (seismic risk zone 2) **OR** greater than or equal to 0.20 (seismic risk zones 3 and 4), **as directed**.
b. Provide earthquake equipment required by ASME A17.1.
c. Design earthquake spectral response acceleration, short period (Sds) for Project is determined by Project's location and site classification.
d. Project's seismic design category is A **OR** B **OR** C **OR** D, **as directed**.
e. Elevator importance factor is 1.5 **OR** 1.0, **as directed**.

4. Accessibility Requirements: Comply with Section 4.10 in the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)" **OR** 407 in ICC A117.1, **as directed**.
5. Fire-Rated Hoistway Entrance Assemblies: Door and frame assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** UBC Standard 7-2 **OR** UL 10B, **as directed**.

F. Delivery, Storage, And Handling
1. Deliver, store, and handle materials, components, and equipment in manufacturer's protective packaging.
2. Store materials, components, and equipment off of ground, under cover, and in a dry location. Handle according to manufacturer's written recommendations to prevent damage, deterioration, or soiling.

G. Coordination
1. Coordinate installation of sleeves, block outs, elevator equipment with integral anchors, and other items that are embedded in concrete or masonry for elevator equipment. Furnish templates, sleeves, elevator equipment with integral anchors, and installation instructions and deliver to Project site in time for installation.
2. Coordinate sequence of elevator installation with other work to avoid delaying the Work.
3. Coordinate locations and dimensions of other work relating to electric traction elevators including pit ladders, sumps, and floor drains in pits; entrance subsills; machine beams, **as directed**; and electrical service, electrical outlets, lights, and switches in pits and machine rooms **OR** hoistways, **as directed**.

H. Warranty
1. Special Manufacturer's Warranty: Manufacturer's standard form in which manufacturer agrees to repair, restore, or replace defective elevator work within specified warranty period.
a. Warranty Period: One year from date of Substantial Completion.

1.2 PRODUCTS

A. Systems And Components
1. General: Provide manufacturer's standard elevator systems. Where components are not otherwise indicated, provide standard components published by manufacturer as included in standard preengineered elevator systems and as required for complete system.
2. Elevator Machines: Provide variable-voltage, variable-frequency, ac-type hoisting machines **OR** At manufacturer's option, provide either variable-voltage, variable-frequency, ac-type or variable-voltage, dc-type hoisting machines, **as directed**. Provide solid-state power converters.
a. Provide regenerative **OR** nonregenerative, **as directed**, system.
b. Limit total harmonic distortion of regenerated power to 5 percent per IEEE 519.
c. Provide means for absorbing regenerated power when elevator system is operating on standby power.
d. Provide line filters or chokes to prevent electrical peaks or spikes from feeding back into building power system.

3. Fluid for Oil Buffers: If oil buffers are used, use only fire-resistant hydraulic fluid containing antioxidant, anticorrosive, antifoaming, and metal-passivating additives.
4. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing guide rails, machinery, and other components of elevator work where installation of devices is specified in another Section.
5. Machine Beams: Provide framing to support elevator hoisting machine and deflector sheaves from the building structure. Comply with Division 5 Section "Metal Fabrications" for materials and fabrication.
6. Car Frame and Platform: Welded steel units.
7. Guides: Provide roller guides **OR** polymer-coated, nonlubricated sliding guides, **as directed**, at top and bottom of car and counterweight frames.

B. Operation Systems
1. General: Provide manufacturer's standard microprocessor operation system for each elevator **OR** for each group of elevators, **as directed**, as required to provide type of operation system indicated.
2. Group Automatic Operation with Demand-Based Dispatching: Provide reprogrammable, **as directed**, group automatic system that assigns cars to hall calls based on a dispatching program designed to minimize passenger waiting time. System automatically adjusts to changes in demand for different traffic conditions including heavy incoming, heavy two-way, heavy outgoing, and light off-hours as variations of normal two-way traffic.
3. Destination-Based Group Automatic Operation: Provide reprogrammable group automatic system that assigns elevators leaving the main lobby in the up direction to a selected group of floors and directs passengers to an elevator serving their destination floor. System dispatches cars in a regulated sequence for optimum system efficiency; dispatch is based on origin and destination of calls. System automatically adjusts to changes in demand for different traffic conditions including heavy incoming, heavy two-way, heavy outgoing, and light off-hours as variations of normal two-way traffic.
4. Auxiliary **OR** Single-Car Auxiliary, **as directed**, Operations: In addition to primary operation system features, provide the following operational features for elevators where indicated:
   a. Standby Power Operation: On activation of standby power, car is returned to a designated floor and parked with doors open. Car can be manually put in service on standby power, either for return operation or for regular operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.
   b. Standby Powered Lowering: On activation of standby power, if car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to the next floor below, opens its doors, and shuts down.
   c. Battery-Powered Lowering: If power fails and car is at a floor, it remains at that floor, opens its doors, and shuts down. If car is between floors, it is lowered to the next floor below, opens its doors, and shuts down. System includes rechargeable battery and automatic recharging system.
   d. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.
   e. Nuisance Call Cancel: When car calls exceed a preset number while car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.
5. Group Auxiliary Operations: In addition to primary operation system features, provide the following operational features for elevators and elevator groups where indicated:
   a. Standby Power Operation: On activation of standby power, cars are returned to a designated floor and parked with doors open. One car is returned at a time, with priority given to loaded cars. If a car cannot be returned after two attempts, it is removed from the system. When all cars have been returned or removed from the system, one car is automatically placed in service. If car selected for service cannot operate within 60 seconds, the system removes car from service and places another car in service. Cars can be manually put in service on standby power, either for return operation or for regular

operation, by switches in control panel located at main lobby **OR** fire command station, **as directed**. Manual operation causes automatic operation to cease.

b. Standby Power Operation: On activation of standby power, cars are returned, one at a time, to a designated floor and parked with doors open. If a car cannot be returned, it is removed from the system. When all cars have been returned or removed from the system, one car can be put in service on standby power by a selector switch in control panel located at main lobby **OR** fire command station, **as directed**.

c. Battery-Powered Lowering: If power fails, cars that are at a floor remain at that floor, open their doors, and shut down. Cars that are between floors are lowered one at a time to the next floor below, open their doors, and shut down. System includes rechargeable battery and automatic recharging system.

d. Automatic Dispatching of Loaded Car: When car load exceeds 80 percent of rated capacity, doors will begin closing.

e. Nuisance Call Cancel: When car calls exceed a preset number while the car load is less than a predetermined weight, all car calls are canceled. Preset number of calls and predetermined weight, **as directed**, can be adjusted.

f. Emergency Hospital **OR** Priority, **as directed**, Service: Service is initiated by a keyswitch **OR** card reader **OR** remote switch, **as directed**, at designated floors. One elevator is removed from group operation and directed to the floor where service was initiated. On arriving at the floor, elevator opens its doors and parks and a lighted sign directs passengers to exit elevator, **as directed**. Car is placed in operation by selecting a floor and pressing door close button or by operating keyswitch to put car in independent service. After responding to floor selected or being removed from independent service, car is returned to group operation. If car is not placed in operation within a preset time after being called, it is returned to group operation.

g. Independent Service: Keyswitch in car control station removes car from group operation and allows it to respond only to car calls. Key cannot be removed from keyswitch when car is in independent service. When in independent service, doors close only in response to door close button.

h. Loaded-Car Bypass: When car load exceeds 80 percent of rated capacity, car will respond only to car calls, not to hall calls.

i. Distributed Parking: When cars are not required for response to calls, they are parked with doors closed, distributed in predetermined zones throughout the building. One zone shall include the main floor and adjacent floors; remaining floors shall be divided into approximately equal zones.

6. Security Features: Provide the following security features, where indicated. Security features shall not affect emergency firefighters' service.

a. Card-Reader Operation: System uses card readers at car control stations **OR** hall push-button stations, **as directed**, to authorize calls. Security system determines which landings and at what times calls require authorization by card reader. Provide required conductors in traveling cable and panel in machine room for interconnecting card readers, other security access system equipment, and elevator controllers. Allow space as indicated for card reader in car **OR** Provide stripe-swipe card reader integral with each car control station, **as directed**.

1) Security access system equipment is specified in Division 13 Section "Security Access".

OR

Security access system equipment is not in the Contract.

b. Keyswitch Operation: Push buttons are activated and deactivated by security keyswitches at car control stations **OR** hall push-button stations, **as directed**. Key is removable only in deactivated position **OR** in either position, **as directed**.

c. Keypad Operation: Allows each landing to be restricted or unrestricted. When a restricted landing button is pressed, a "Restricted Floor" lamp lights and remains lit until landing access code has been entered into a keypad or predetermined time period has elapsed.

Car calls for restricted landings do not register until landing access code is entered into keypad within predetermined time period after landing button is pressed.

1) Access codes are programmed at each car operating panel using a security keyswitch. Keypad operation can be activated and deactivated by security keyswitch at main landing.

d. Car-to-Lobby Feature: Feature, activated by keyswitch at main lobby, that causes car **OR** all cars in a group, **as directed**, to return immediately to lobby and open doors for inspection. On deactivation by keyswitch, calls registered before keyswitch activation are completed and normal operation is resumed.

C. Door Reopening Devices

1. Infrared Array: Provide door reopening devices with uniform array of 36 or more microprocessor-controlled, infrared light beams projecting across car entrance. Interruption of one or more of the light beams shall cause doors to stop and reopen.
2. Nudging Feature: After car doors are prevented from closing for predetermined adjustable time, through activating door reopening device, a loud buzzer shall sound and doors shall begin to close at reduced kinetic energy.

D. Finish Materials

1. General: Provide the following materials for exposed parts of elevator car enclosures, car doors, hoistway entrance doors and frames, and signal equipment as indicated.
2. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel, Type B, exposed, matte finish.
3. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel, Type B, pickled.
4. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304.
   a. Textured Stainless-Steel Sheet: Product with coined **OR** embossed, **as directed**, texture rolled into exposed surface.
      1) Metal surface is satin polished **OR** satin relieved **OR** titanium nitride colored **OR** oxide colored **OR** satin polished and titanium nitride colored **OR** satin relieved and titanium nitride colored **OR** satin polished and oxide colored **OR** satin relieved and oxide colored **OR** color coated and satin relieved **OR** color coated and bright relieved, **as directed**, after rolling.
5. Stainless-Steel Bars: ASTM A 276, Type 304.
6. Stainless-Steel Tubing: ASTM A 554, Grade MT 304.
7. Bronze Plate and Sheet: ASTM B 36/B 36M, Alloy UNS No. C28000 (muntz metal).
8. Bronze Extrusions: ASTM B 455, Alloy UNS No. C38500 (architectural bronze).
9. Bronze Tubing: ASTM B 135 (ASTM B 135M), Alloy UNS No. C23000 (red brass, 85 percent copper).
10. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063.
11. Nickel Silver Extrusions: ASTM B 151/B 151M, Alloy UNS No. C74500 or No. C77600.
12. Plastic Laminate: High-pressure type complying with NEMA LD 3, Type HGS for flat applications **OR** Type HGL for flat applications, **as directed**, Type HGP for postformed applications and Type BKV for panel backing.

E. Car Enclosures

1. General: Provide enameled-steel car enclosures to receive removable **OR** steel-framed car enclosures with nonremovable, **as directed**, wall panels, with car **OR** removable car, **as directed**, roof, access doors, power door operators, and ventilation.
   a. Provide standard railings complying with ASME A17.1 on car tops where required by ASME A17.1.
   b. Provide finished car including materials and finishes specified below.
2. Materials and Finishes: Provide manufacturer's standards, but not less than the following:
   a. Subfloor: Underlayment grade, exterior plywood, 5/8-inch (16-mm) nominal thickness.
   b. Floor Finish: Specified in a Division 9 Section **OR** Elevator manufacturer's standard level-loop nylon carpet; color as selected from manufacturer's full range, **as directed**.

c. Enameled-Steel Wall Panels: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
d. Stainless-Steel Wall Panels: Flush, hollow-metal construction; fabricated from stainless-steel sheet.
e. Bronze Wall Panels: Flush, hollow-metal construction; fabricated from bronze sheet.
f. Plastic-Laminate Wall Panels: Plastic laminate adhesively applied to 1/2-inch (13-mm) fire-retardant-treated particleboard **OR** manufacturer's standard honeycomb core, **as directed**, with plastic-laminate panel backing and, **as directed**, manufacturer's standard protective edge trim. Panels have a flame-spread index of 25 **OR** 75, **as directed**, or less, when tested according to ASTM E 84. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
g. Fabricate car with recesses and cutouts for signal equipment.
h. Fabricate car door frame integrally with front wall of car.
i. Enameled-Steel Doors: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
j. Stainless-Steel Doors: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
k. Bronze Doors: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
l. Plastic-Laminate Doors: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching return panels, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
m. Sight Guards: Provide sight guards on car doors.
n. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
o. Luminous Ceiling: Fluorescent light fixtures and ceiling panels of translucent acrylic or other permanent rigid plastic.
p. Metal **OR** Metallic-Finish, Plastic-Laminate, **as directed**, Ceiling: Flush panels, with incandescent downlights in the center of **OR** four low-voltage downlights in, **as directed**, each panel. Align ceiling panel joints with joints between wall panels, **as directed**.
q. Handrails: Manufacturer's standard handrails, of shape, metal, and finish indicated.

F. Hoistway Entrances
1. General: Provide manufacturer's standard horizontal-sliding, door-and-frame hoistway entrances complete with track systems, hardware, sills, and accessories. Provide frame size and profile to coordinate with hoistway wall construction.
   a. Where gypsum board wall construction is indicated, provide self-supporting frames with reinforced head sections.
2. Materials and Fabrication: Provide manufacturer's standards, but not less than the following:
   a. Enameled-Steel Frames: Formed from cold-rolled or hot-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
   b. Steel Subframes: Formed from cold-rolled or hot-rolled steel sheet with factory-applied enamel finish or corrosion-inhibiting primer. Fabricate to receive applied finish as indicated.
   c. Stainless-Steel Frames: Formed from stainless-steel sheet.
   d. Bronze Frames: Formed from cold-rolled or hot-rolled steel sheet, with enamel finish, and with formed-bronze sheet laminated to steel frames using adhesive that fully bonds metal to metal without telegraphing or oil-canning.

e. Enameled-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from cold-rolled steel sheet. Provide with factory-applied enamel finish; colors as selected from manufacturer's full range.
f. Stainless-Steel Doors and Transoms: Flush, hollow-metal construction; fabricated from stainless-steel sheet **OR** by laminating stainless-steel sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning, **as directed**.
g. Bronze Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating bronze sheet to exposed faces and edges of enameled cold-rolled steel doors using adhesive that fully bonds metal to metal without telegraphing or oil-canning.
h. Plastic-Laminate Doors and Transoms: Flush, hollow-metal construction; fabricated by laminating plastic laminate to exposed faces of enameled cold-rolled steel doors and covering edges with protective edge trim matching door frames, **as directed**. Plastic-laminate color, texture, and pattern as selected from plastic-laminate **OR** elevator, **as directed**, manufacturer's full range.
i. Sight Guards: Provide sight guards on doors matching door edges.
j. Sills: Extruded metal, with grooved surface, 1/4 inch (6.4 mm) thick.
k. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.

G. Signal Equipment
1. General: Provide hall-call and car-call buttons that light when activated and remain lit until call has been fulfilled. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
OR
General: Provide signal equipment designed for destination-based system. Fabricate lighted elements with long-life incandescent lamps and acrylic or other permanent, nonyellowing translucent plastic diffusers **OR** LEDs, **as directed**.
2. Car Control Stations: Provide manufacturer's standard recessed **OR** semirecessed, **as directed**, car control stations. Mount in return panel adjacent to car door, unless otherwise indicated.
OR
Swing-Return Car Control Stations: Provide car control stations mounted on rear of hinged return panel adjacent to car door and with buttons, switches, controls, and indicator lights projecting through return panel but substantially flush with face of return panel.
a. Mark buttons and switches with standard identification for required use or function that complies with ASME A17.1. Use both tactile symbols and Braille.
b. Provide "No Smoking" sign matching car control station, either integral with car control station or mounted adjacent to it, with text and graphics as required by authorities having jurisdiction.
3. Emergency Communication System: Provide system that complies with ASME A17.1 and the U.S. Architectural & Transportation Barriers Compliance Board's "Americans with Disabilities Act (ADA), Accessibility Guidelines for Buildings and Facilities (ADAAG)." On activation, system dials preprogrammed number of monitoring station and identifies elevator location to monitoring station. System provides two-way voice communication without using a handset and provides visible signals that indicate when system has been activated and when monitoring station has responded. System is contained in flush-mounted cabinet, with identification, instructions for use, and battery backup power supply.
4. Firefighters' Two-Way Telephone Communication Service: Provide flush-mounted cabinet **OR** telephone jack, **as directed**, in each car and required conductors in traveling cable for firefighters' two-way telephone communication service specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".
5. Car Position Indicator: Provide illuminated, **as directed**, digital-type car position indicator, located above car door or above car control station. Also provide audible signal to indicate to passengers that car is either stopping at or passing each of the floors served.
a. Include travel direction arrows if not provided in car control station.

6. Hall Push-Button Stations: Provide one hall push-button station at each landing for each single elevator or group of elevators, but not less than one station for each four elevators in a group, **as directed**.
   OR
   Hall Push-Button Stations: Provide hall push-button stations at each landing as indicated.
   a. Provide manufacturer's standard wall-mounted units.
      OR
      Provide units with flat faceplate for mounting with body of unit recessed in wall.
   b. Equip units with buttons for calling elevator and for indicating desired direction of travel.
      OR
      Equip units with buttons **OR** touch screen, **as directed**, for calling elevator and for indicating direction of travel or destination as required by system. Provide a signaling system to verify floor selection, where destination registration is required, and to direct passengers to appropriate car.
      1) Provide a means for passengers to indicate that they have disabilities so control system can allow extra room in assigned car.
      2) Provide for connecting units that require destination registration to building security access system so a card reader can be used to register calls.
   c. Provide telephone jack in each unit for firefighters' two-way telephone communication service specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System".
7. Hall Lanterns: Units with illuminated arrows; but provide single arrow at terminal landings. Provide one of the following:
   a. Manufacturer's standard wall-mounted units, for mounting above entrance frames.
   b. Units with flat faceplate for mounting with body of unit recessed in wall and with illuminated elements projecting from faceplate for ease of angular viewing.
   c. Units mounted in both jambs of entrance frame for each elevator, **as directed**.
   d. Units mounted in both car door jambs; may be used only for single elevators or for two-car groups, **as directed**.
8. Hall Annunciator: With each hall lantern, provide audible signals indicating car arrival and direction of travel. Signals sound once for up and twice for down.
   a. At manufacturer's option, audible signals may be placed on car **OR** each car, **as directed**.
9. Hall Position Indicators: Provide illuminated, **as directed**, digital-display-type position indicators, located above each, **as directed**, hoistway entrance at ground floor. Provide units with flat faceplate for mounting with body of unit recessed in wall.
   a. Integrate ground-floor hall lanterns with hall position indicators.
10. Standby Power Elevator Selector Switches: Provide switches, as required by ASME A17.1, where indicated. Adjacent to switches, provide illuminated signal that indicates when normal power supply has failed. For each elevator, provide illuminated signals that indicate when they are operational and when they are at the designated emergency return level with doors open.
    OR
    Fire Command Center Annunciator Panel: Provide panel containing illuminated position indicators for each elevator, clearly labeled with elevator designation; include illuminated signal that indicates when elevator is operational and when it is at the designated emergency return level with doors open. Provide standby power elevator selector switch(es), as required by ASME A17.1, adjacent to position indicators. Provide illuminated signal that indicates when normal power supply has failed.
11. Corridor Call Station Pictograph Signs: Provide signs matching hall push-button stations, with text and graphics as required by authorities having jurisdiction, indicating that in case of fire elevators are out of service and exits should be used instead. Provide one sign at each hall push-button station, unless otherwise indicated.

H. Elevators
   1. Elevator Description:

a. Group Number: <**Insert a different number for each group of elevators that share a group operation system.**>
b. Elevator Number(s): <**Insert elevator number(s) as shown on Drawings.**>
c. Service Elevator Number(s): <**Insert elevator number(s) as shown on Drawings.**>
d. Type: Geared **OR** Gearless, **as directed**, traction.
e. Machine Location: Machine room above hoistway **OR** Hoistway; no machine room is provided, **as directed**.
f. Rated Load: 2000 lb (908 kg) **OR** 2100 lb (953 kg) **OR** 2500 lb (1135 kg) **OR** 3000 lb (1362 kg) **OR** 3500 lb (1589 kg) **OR** 4000 lb (1816 kg) **OR** 4500 lb (2043 kg) **OR** 5000 lb (2270 kg), **as directed**.
g. Freight Loading Class for Service Elevator(s): Class A.
h. Rated Speed: 200 fpm (1.0 m/s) **OR** 350 fpm (1.8 m/s) **OR** 400 fpm (2.0 m/s) **OR** 450 fpm (2.3 m/s) **OR** 500 fpm (2.5 m/s) **OR** 700 fpm (3.6 m/s) **OR** 800 fpm (4.1 m/s) **OR** 1000 fpm (5.1 m/s) **OR** 1200 fpm (6.1 m/s) **OR** 1400 fpm (7.1 m/s), **as directed**.
i. Operation System: Selective collective automatic operation **OR** Group automatic operation **OR** Group automatic operation with demand-based dispatching **OR** Destination-based group automatic operation, **as directed**.
j. Auxiliary Operations:
   1) Standby power operation.
   2) Standby powered lowering.
   3) Battery-powered lowering.
   4) Earthquake Emergency Operation: Comply with requirements in ASME A17.1.
   5) Automatic dispatching of loaded car.
   6) Nuisance call cancel.
   7) Emergency hospital **OR** Priority, **as directed**, service at designated floors **OR** all floors, **as directed**.
   8) Independent service for service elevator **OR** all cars in group, **as directed**.
   9) Loaded-car bypass.
   10) Distributed parking.
k. Security Features: Card-reader operation **OR** Keyswitch operation **OR** Keypad operation **OR** Car-to-lobby feature, **as directed**.
l. Dual Car Control Stations: Provide two car control stations in each elevator, **aas directed**; equip only one with required keyswitches if any.
m. Car Enclosures:
   1) Inside Width: 64 inches (1626 mm) **OR** 68 inches (1727 mm) **OR** 80 inches (2032 mm) **OR** 92 inches (2337 mm), **as directed**, from side wall to side wall.
   2) Inside Depth: 51 inches (1295 mm) **OR** 53 inches (1346 mm) **OR** 57 inches (1448 mm) **OR** 65 inches (1651 mm) **OR** 87-1/2 inches (2222 mm) **OR** 90 inches (2286 mm) **OR** 93 inches (2362 mm) **OR** 93-1/2 inches (2375 mm) **OR** 96 inches (2438 mm) **OR** 101 inches (2565 mm) **OR** 102 inches (2591 mm), **as directed**, from back wall to front wall (return panels).
   3) Inside Height: 88 inches (2235 mm) **OR** 92 inches (2337 mm) **OR** 94 inches (2388 mm) **OR** 100 inches (2540 mm) **OR** 104 inches (2642 mm) **OR** 108 inches (2743 mm) **OR** 112 inches (2845 mm), **as directed**, to underside of ceiling.
   4) Front Walls (Return Panels): Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
   5) Car Fixtures: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
   6) Side and Rear Wall Panels: Enameled steel **OR** Plastic laminate **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel, **as directed**.
   7) Reveals: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.

8) Door Faces (Interior): Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
9) Door Sills: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
10) Ceiling: Luminous ceiling **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Reflective metallic-finish, plastic-laminate, stainless steel **OR** Reflective metallic-finish, plastic-laminate, bronze, **as directed**.
11) Handrails: 1-1/2 inches (38 mm) round **OR** 1/2 by 2 inches (13 by 50 mm) rectangular, **as directed**, mirror-polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** mirror-polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**, at sides **OR** rear **OR** sides and rear, **as directed**, of car.
12) Floor: Manufacturer's standard carpet.
OR
Floor prepared to receive carpet (specified in Division 09 Section "Carpet").
OR
Floor prepared to receive resilient tile (specified in Division 09 Section "Resilient Floor Tile").
OR
Floor prepared to receive sheet vinyl (specified in Division 09 Section "Resilient Sheet Flooring").
OR
Floor recessed and prepared to receive dimension stone tile (specified in Division 09 Section "Dimension Stone Tile") **OR** ceramic tile (specified in Division 09 Section "Ceramic Tile"), **as directed**.
13) Floor Thickness, Including Setting Materials: <**Insert thickness**> above plywood subfloor.

n. Hoistway Entrances: As follows:
1) Width: 36 inches (914 mm) **OR** 42 inches (1067 mm) **OR** 48 inches (1219 mm) **OR** 54 inches (1372 mm), **as directed**.
2) Height: 84 inches (2134 mm) **OR** 96 inches (2438 mm), **as directed**.
3) Type: Single-speed side sliding **OR** Two-speed side sliding **OR** Single-speed center opening **OR** Two-speed center opening, **as directed**.
4) Fire-Protection Rating: 1 hour **OR** 1-1/2 hours, **as directed**, with 30-minute temperature rise of 450 deg F (250 deg C), **as directed**.
5) Frames at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
6) Frames at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered, **as directed**.
7) Doors and Transoms at First Floor **OR** at Basement Floors, **as directed**: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
8) Doors and Transoms at Other Floors: Enameled steel **OR** Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Textured stainless steel **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Plastic laminate, **as directed**.
9) Sills at First Floor **OR** at Basement Floors, **as directed**: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.
10) Sills at Other Floors: Aluminum, mill finish **OR** Bronze, polished **OR** Nickel silver, polished, **as directed**.

o. Hall Fixtures at First Floor **OR** at Basement Floors, **as directed**: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.

p. Hall Fixtures at Other Floors: Polished stainless steel, No. 8 finish **OR** Satin stainless steel, No. 4 finish **OR** Polished bronze, lacquered **OR** Satin bronze, lacquered **OR** Recessed type with no exposed-metal surfaces, **as directed**.

q. Additional Requirements:

1) Provide inspection certificate in each car, mounted under acrylic cover with frame made from polished stainless steel, No. 8 finish **OR** satin stainless steel, No. 4 finish **OR** polished bronze, lacquered **OR** satin bronze, lacquered, **as directed**.

2) Provide blanket hooks in all cars, **as directed**, and one **OR** two, **as directed**, complete set(s) of full-height protective blankets.

1.3 EXECUTION

A. Examination

1. Examine elevator areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance. Examine hoistways, hoistway openings, pits, and machine rooms as constructed; verify critical dimensions; and examine supporting structure and other conditions under which elevator work is to be installed.

a. For the record, prepare a written report, endorsed by Installer, listing dimensional discrepancies and conditions detrimental to performance or indicating that dimensions and conditions were found to be satisfactory.

b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Comply with manufacturer's written instructions.
2. Welded Construction: Provide welded connections for installing elevator work where bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, and replacement of worn parts. Comply with AWS standards for workmanship and for qualifications of welding operators.
3. Sound Isolation: Mount rotating and vibrating equipment on vibration-isolating mounts designed to minimize transmission of vibrations to structure and thereby minimize structure-borne noise from elevator system.
4. Lubricate operating parts of systems, including ropes, as recommended by manufacturers.
5. Alignment: Coordinate installation of hoistway entrances with installation of elevator guide rails for accurate alignment of entrances with car. Where possible, delay final adjustment of sills and doors until car is operable in shaft. Reduce clearances to minimum, safe, workable dimension at each landing.
6. Leveling Tolerance: 1/8 inch (3 mm), up or down, regardless of load and direction of travel.
7. Set sills flush with finished floor surface at landing. Fill space under sill solidly with nonshrink, nonmetallic grout.
8. Locate hall signal equipment for elevators as follows, unless otherwise indicated:

a. For groups of elevators, locate hall push-button stations between two elevators at center of group or at location most convenient for approaching passengers.

b. Place hall lanterns either above or beside each hoistway entrance.

c. Mount hall lanterns at a minimum of 72 inches (1829 mm) above finished floor.

C. Field Quality Control

1. Acceptance Testing: On completion of elevator installation and before permitting use (either temporary or permanent) of elevators, perform acceptance tests as required and recommended by ASME A17.1 and by governing regulations and agencies.
2. Operating Test: Load elevator **OR** each elevator **OR** one elevator of each type, capacity, speed, and travel distance, **as directed**, to rated capacity and operate continuously for 30 minutes over full travel distance, stopping at each level and proceeding immediately to the next. Record

temperature rise of elevator machine during 30-minute test period. Record failure to perform as required.

3. Advise Owner and authorities having jurisdiction in advance of dates and times tests are to be performed on elevators.

D. Protection

1. Temporary Use: Limit temporary use for construction purposes to one elevator **as directed**. Comply with the following requirements for each, **as directed**, elevator used for construction purposes:
   a. Provide car with temporary enclosure, either within finished car or in place of finished car, to protect finishes from damage.
   b. Provide strippable protective film on entrance and car doors and frames.
   c. Provide padded wood bumpers on entrance door frames covering jambs and frame faces.
   d. Provide other protective coverings, barriers, devices, signs, and procedures as needed to protect elevator and elevator equipment.
   e. Do not load elevators beyond their rated weight capacity.
   f. Engage elevator Installer to provide full maintenance service. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as necessary for proper elevator operation at rated speed and capacity. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
   g. Engage elevator Installer to restore damaged work, if any, so no evidence remains of correction. Return items that cannot be refinished in the field to the shop, make required repairs and refinish entire unit, or provide new units as required.

E. Demonstration

1. Train Owner's maintenance personnel to operate, adjust, and maintain elevator(s).
2. Check operation of each elevator with Owner's personnel present and before date of Substantial Completion. Determine that operation systems and devices are functioning properly.
3. Check operation of each elevator with Owner's personnel present not more than one month before end of warranty period. Determine that operation systems and devices are functioning properly.

END OF SECTION 14290

Task	Specification	Specification Description
14290	14240	Hydraulic Elevators

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SECTION 14420 - WHEELCHAIR LIFTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for wheelchair lifts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Vertical and Private-residence, vertical platform lifts.
b. Inclined and Private-residence, inclined platform lifts.
c. Inclined and Private-residence, inclined stairway chairlifts.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For each lift. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each type of exposed finish required.
4. Manufacturer Certificates: Signed by lift manufacturer certifying that runway, ramp or pit, and dimensions as shown on Drawings and that electrical service as shown and specified are adequate for lift being provided.
5. Inspection and Acceptance Certificates and Operating Permits: As required by authorities having jurisdiction for normal, unrestricted use of lifts.
6. Operation and Maintenance Data: For each type of lift to include in operation and maintenance manuals.
7. Warranty: Sample of special warranty.
8. Continuing maintenance proposal.

D. Quality Assurance
1. Regulatory Requirements: In addition to requirements of authorities having jurisdiction, comply with ASME A18.1, "Safety Standard for Platform Lifts and Stairway Chairlifts."
2. Fire-Rated, Runway-Enclosure Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at as close to neutral pressure as possible according to NFPA 252 **OR** UBC Standard 7-2 **OR** UL 10B, **as directed**.
a. Temperature-Rise Limit: Provide doors that have a maximum transmitted temperature end point of not more than 450 deg F (250 deg C) above ambient after 30 minutes of standard fire-test exposure.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lifts that fail in materials or workmanship within two **OR** Four **OR** Five, **as directed**, years from date of Substantial Completion.

F. Maintenance Service
1. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of lift Installer. Include quarterly preventive maintenance and repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as

required for proper lift operation at rated speed and capacity. Provide parts and supplies the same as those used in the manufacture and installation of original equipment.

2. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly **OR** two-year **OR** five-year, **as directed**, maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.2 PRODUCTS

A. Materials
1. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
2. Steel Tubing: ASTM A 500.
3. Steel Pipe: ASTM A 53/A 53M; standard weight (Schedule 40) unless otherwise indicated or required by structural loads.
4. Cold-Rolled Steel Sheet: ASTM A 1008/A 1008M, commercial steel (CS), Type B, exposed, matte finish.
5. Hot-Rolled Steel Sheet: ASTM A 1011/A 1011M, commercial steel (CS), Type B, pickled.
6. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating,
7. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:
   a. ASTM A 123/A 123M, for galvanizing steel and iron products.
   b. ASTM A 153/A 153M, for galvanizing steel and iron hardware.
8. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required:
   a. Extruded Aluminum: ASTM B 221 (ASTM B 221M), Alloy 6063-T6.
   b. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 5005-H15.
9. Stainless-Steel Bars and Shapes: ASTM A 276, Type 304.
10. Stainless-Steel Tubing: ASTM A 554, Grade MT-304.
11. Stainless-Steel Sheet, Strip, and Plate: ASTM A 240/A 240M or ASTM A 666, Type 304.
12. Stainless-Steel Floor Plate: ASTM A 793.
13. Wood and Wood Panel Products: Comply with requirements in Division 06 Section "Interior Architectural Woodwork".
14. Wood and Wood Panel Products:
   a. Wood: Clear, vertical-grain, straight, kiln-dried wood, AWPA C20-02, Interior Type A, fire-retardant treated, **as directed**; of manufacturer's standard species.
   b. Wood Panels: Provide wood panels consisting of wood veneer and wood panel as follows:
      1) Wood Veneer: Laminated to core with moisture-resistant adhesive.
      2) Plywood: DOC PS 1.
      3) Particleboard: ANSI A208.1, made with binder containing no urea formaldehyde, **as directed**.
      4) Medium-Density Fiberboard: ANSI A208.2, made with binder containing no urea formaldehyde, **as directed**.
   c. Fire-Retardant-Treated Wood Panels: Provide wood panels consisting of wood veneer and AWPA C27-02 fire-retardant-treated wood panels. Panels shall have flame-spread index of 75 **OR** 25, **as directed**, or less and smoke-developed index of 450 or less per ASTM E 84.
      1) Wood Veneer: Laminated to core with moisture-resistant adhesive.
      2) Plywood: DOC PS 1.
      3) Particleboard: ANSI A208.1, made with binder containing no urea formaldehyde, **as directed**.
      4) Medium-Density Fiberboard: ANSI A208.2, made with binder containing no urea formaldehyde, **as directed**.

15. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light-stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and manufacturer's standard finish.
16. Glass:
    a. Comply with requirements in Division 08 Section "Glazing".
       OR
       As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**, and complying with ASME A18.1.
       1) Safety Glazing Products: Comply with testing requirements in 16 CFR 1201, Category II.
       2) Safety Glass Marking: Glass permanently marked with certification label of SGCC or another certification agency or manufacturer acceptable to authorities having jurisdiction.
17. Acrylic Glazing: ASTM D 4802, Category A-1 (cell-cast) or Category A-2 (continuous cast), Finish 1 (smooth or polished), clear or tinted as indicated.
18. Inserts: Furnish required concrete and masonry inserts and similar anchorage devices for installing structural members, guide rails, machines, and other lift components where installation of devices is specified in another Section.
19. Expansion Anchors: Anchor-bolt-and-sleeve assembly of material indicated below with capability to sustain a load equal to 10 times the load imposed as determined by testing per ASTM E 488 conducted by a qualified independent testing agency.
    a. Material:
       1) Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.
          OR
          Group 1, Alloy 304 or Alloy 316, stainless-steel bolts and nuts complying with ASTM F 593 (ASTM F 738M) and ASTM F 594 (ASTM F 836M).
20. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.

B. Vertical Platform Lifts
1. Private-Residence, **as directed**, Vertical Platform Lifts: Manufacturer's standard preengineered lift systems as indicated.
2. Platform Size: 34 by 54 inches (864 by 1372 mm) **OR** 35 by 48 inches (889 by 1220 mm) **OR** 35 by 51 inches (889 by 1295 mm) **OR** 36 by 56 inches (914 by 1422 mm) **OR** 36 by 60 inches (914 by 1524 mm), **as directed**.
3. Door Operation and Clear Opening Width: Low-energy, power-operated doors that remain open for 20 seconds minimum; end door with minimum 32-inch (815-mm) and side door with minimum 42-inch (1065-mm) clear opening width.
4. Rated Speed: 8 fpm (0.04 m/s)\ **OR** 10 fpm (0.05 m/s) **OR** 12 fpm (0.06 m/s) **OR** 15 fpm (0.08 m/s) **OR** 20 fpm (0.10 m/s) **OR** 22 fpm (0.11 m/s) **OR** 30 fpm (0.15 m/s), **as directed**.
5. Power Supply: 208 V, 60 Hz, 3 phase **OR** 240 V, 60 Hz, 1 phase **OR** 120 V, 60 Hz, 1 phase, **as directed**.
6. Emergency Operation: Provide emergency manual operation and emergency battery power system **OR** connection to indicated standby (emergency) power, **as directed**, to raise or lower units in case of malfunction or power loss.
7. Attendant Operation: Provide attendant operation at location shown.
8. Self-Supporting Units: Support vertical loads of units only at base, with lateral support only at landing levels.
9. Partial, **as directed**, Runway Enclosure: Manufacturer's standard weather-resistant, **as directed**, enclosure assembly.
   a. Runway Enclosure: One of the following, **as directed.**
      1) Rectangular steel-tube frame with flush steel-sheet panels.
      2) Rectangular hot-dip-galvanized steel-tube frame with flush galvanized-steel-sheet panels.
      3) Extruded-aluminum frame with flush galvanized-steel-sheet panels.

4) Extruded-aluminum frame with flush aluminum-sheet panels; with hot-dip-galvanized steel-tube frame for structural framing that cannot be aluminum.
5) Rectangular steel-tube frame with wood panels and trim.
6) Rectangular wood frame with wood panels and trim.
7) Rectangular steel-tube frame with fiberglass panels.

b. Glazed Runway Enclosure: Rectangular structure of glazed extruded-aluminum framing with a tinted, acrylic dome roof.
1) Glazing:
a) Bronze-tinted acrylic glazing, 6.0 mm thick.
OR
Bronze-tinted, float glass **OR** tempered safety **OR** laminated safety, **as directed**, glass, 6.0 mm thick, where indicated.

c. Runway-Enclosure Doors: One of the following, **as directed**:
1) Rectangular steel-tube frames with flush steel-sheet panels.
2) Rectangular steel-tube frames glazed with 6.0-mm-thick, clear acrylic glazing and with 12-inch- (300-mm-) high, steel kick panels.
3) Wide-stile aluminum entrance doors glazed with bronze-tinted tempered safety glass, 6.0 mm thick.
4) Enclosure doors matching appearance of adjacent glass-supported railings, complying with Division 05 Section "Ornamental Railings".

d. Fire-Rated Runway-Enclosure Door: Provide fire-rated runway-enclosure door where shown **OR** at upper landing **OR** at lower landing, **as directed**.
1) Fire-Protection Rating: 1-1/2 hours.
2) Equip door with wired glass vision panel, delay-action door closer, dead latch, dummy trim door handle, and electric strike.

10. Platform: One of the following, **as directed:**
a. Galvanized-steel sheet with black rubber flooring.
b. Stainless-steel floor plate with checkered texture.
c. Aluminum floor plate with nonskid surface texture.

11. Platform Low-Profile Carriage: Fabricate platform floor assembly to total thickness not exceeding 1-1/2 inches (38 mm).

12. Platform Enclosure and Door: One of the following, **as directed:**
a. Rectangular steel-tube frame with flush steel-sheet panels.
b. Rectangular hot-dip-galvanized steel-tube frame with flush galvanized-steel-sheet panels.
c. Extruded-aluminum frame with flush galvanized-steel-sheet panels.
d. Extruded-aluminum frame with flush aluminum-sheet panels; with hot-dip-galvanized steel-tube frame for structural framing that cannot be aluminum.
e. Rectangular steel-tube frame with wood panels and trim.
f. Rectangular steel-tube frame with fiberglass panels.
g. Enclosure walls and doors matching appearance of adjacent glass-supported railings, complying with Division 05 Section "Ornamental Railings".

13. Platform Top: Provide a non-load-bearing top, matching construction of enclosure walls. Permanently mark top to indicate that it cannot sustain a load.

14. Fixed Ramp: Provide fixed ramp matching platform to provide transition from floor to lift platform at bottom landing.

15. Retractable Ramp: Provide ramp matching platform to provide transition from lower floor to lift platform. Ramp lowers to floor automatically when lifts reach lower landing and door opens. Ramp rises automatically when lift control is activated for lift to leave lower landing.
a. Ramp Size: End ramps a minimum of 32 inches (815 mm) and side ramps a minimum of 42 inches (1065 mm) wide; length as required for slope.
b. Ramp Slope: As indicated **OR** Maximum 1:12, **as directed**.
c. Ramp Finish: Finish ramps to match lift platform **OR** Ramp finish is specified elsewhere as indicated, **as directed**.

16. Accessories: Provide units with the following accessories:
a. Fold-down seat with armrests and safety belt.

b. Forced Ventilation System: Minimum 1 air change per minute, continuously operating **OR** thermostatically controlled to activate at 90 deg F (32.22 deg C) , **as directed**, and with auxiliary power source to operate ventilation for 1 hour in case of power failure.

c. Lighting system within lift enclosures as indicated on Drawings **OR** selected from manufacturer's available products, **as directed**.

C. Inclined Platform Lifts

1. Private-Residence, **as directed**, Inclined Platform Lifts: Manufacturer's standard preengineered lift systems as indicated.
2. Platform Size: 29 by 33 inches (737 by 838 mm) **OR** 28 by 35 inches (711 by 889 mm) **OR** 30 by 35 inches (760 by 889 mm) **OR** 30 by 36 inches (760 by 914 mm) **OR** 31 by 39 inches (787 by 991 mm) **OR** 30 by 41 inches (760 by 1041 mm) **OR** 30 by 42 inches (760 by 1067 mm) **OR** 31 by 43 inches (787 by 1092 mm) **OR** 30 by 48 inches (760 by 1220 mm), **as directed**.
3. Door Operation and Clear Opening Width: Low-energy, power-operated doors that remain open for 20 seconds minimum; end door with minimum 32-inch (815-mm) and side door with minimum 42-inch (1065-mm) clear opening width.
4. Rated Speed: 20 fpm (0.10 m/s) **OR** 22 fpm (0.11 m/s) **OR** 25 fpm (0.13 m/s) **OR** 30 fpm (0.15 m/s), **as directed**.
5. Minimum Headroom Clearance during Travel: Minimum of 80 inches (2032 mm) above any point on platform floor.
6. Power Supply: 208 V, 60 Hz, 3 phase **OR** 240 V, 60 Hz, 1 phase **OR** 120 V, 60 Hz, 1 phase, **as directed**.
7. Emergency Operation: Provide emergency manual operation and emergency battery power system **OR** connection to indicated standby (emergency) power, **as directed**, to raise or lower units in case of malfunction or power loss.
8. Attendant Operation: Provide attendant operation at location shown.
9. Platform: One of the following, **as directed:**
   a. Galvanized-steel sheet with black rubber flooring.
   b. Stainless-steel floor plate with checkered texture.
   c. Aluminum floor plate with nonskid surface texture.
10. Automatic Folding Platforms: When not in use, platforms automatically fold up against wall to minimize projection into stairway.
11. Manual Folding Platforms: When not in use, platforms can be folded up against wall to minimize projection into stairway.
12. Platform Guarding: Guard platform with passenger restraining arms **OR** enclosure, **as directed**.
    a. Passenger Restraining Arms: Steel **OR** Galvanized-steel **OR** Stainless-steel, **as directed**, tubing, manually **OR** power, **as directed**, operated.
    b. Platform Enclosure (Side Walls and Self-Closing Door): One of the following, **as directed**:
       1) Rectangular steel-tube frame with flush steel-sheet panels.
       2) Enclosure walls and doors matching appearance of adjacent glass-supported railings, complying with Division 05 Section "Ornamental Railings".
13. Platform Guarding: Guard platform with automatically **OR** manually, **as directed**, actuated, retractable metal guard on lower access end of platform.
14. Fixed Ramp: Provide fixed ramp matching platform to provide transition from floor to lift platform at bottom landing.
15. Retractable Ramp: Provide ramp matching platform to provide transition from floor to lift platform. Ramp lowers to floor automatically when lifts reach landing and enclosure door opens. Ramp rises automatically when lift control is activated for lift to leave landing.
    a. Ramp Size: End ramps a minimum of 32 inches (815 mm) and side ramps a minimum of 42 inches (1065 mm) wide; length as required for slope.
    b. Ramp Slope: As indicated **OR** Maximum 1:12, **as directed**.
    c. Ramp Finish: Finish ramps to match lift platform **OR** Ramp finish is specified elsewhere as indicated, **as directed**.
16. Supporting Structure: Provide framing to support vertical loads from floor or stair treads and only lateral loads from walls. Fabricate framing from steel **OR** stainless-steel, **as directed**, rectangular tubing, plates, shapes, and bars.

17. Guide Rails: Fabricate from steel **OR** stainless-steel, **as directed**, tubing.
18. Accessories: Provide units with the following accessories:
    a. Fold-down seat with armrests and safety belt.
    b. Caution sign as required by ASME A18.1.

D. Inclined Stairway Chairlifts
1. Private-Residence, **as directed**, Inclined Stairway Chairlifts: Manufacturer's standard preengineered lift systems as indicated.
2. Systems and Machinery: Manufacturer's standard preengineered lift systems as indicated in published product literature and as follows:
    a. Rated Capacity: Minimum 250 lb (113 kg) **OR** 400 lb (181 kg), **as directed**.
    b. Rated Speed: 18 fpm (0.09 m/s) **OR** 20 fpm (0.10 m/s) **OR** 22 fpm (0.11 m/s) **OR** 25 fpm (0.13 m/s), **as directed**.
3. Power Supply: 120 V, 60 Hz, 1 phase.
4. Battery Operation: Provide battery-operated drive with automatic charging system.
5. Manual Lowering: Provide means to manually lower units in case of malfunction or power loss.
6. Folding Units: Provide units that can be folded up against wall when not in use, to minimize projection into stairway.
7. Supporting Structure: Provide brackets to support vertical loads from floor or stair treads and to support lateral loads from walls. Fabricate brackets from steel plates, shapes, or bars.
8. Accessories: Provide units with the following accessories:
    a. Tubular-steel, manually operated safety arms designed to restrain and provide grab bar for occupant.
    b. Retractable seat belt.
    c. Seat with back and two handgrips or arms.

E. General Finish Requirements
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
2. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
3. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

F. Finishes
1. Steel and Galvanized-Steel Factory Finish:
    a. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard 2-coat, baked-on finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat.
    b. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard, thermosetting polyester or acrylic urethane powder coating with a cured film thickness not less than 1.5 mils (0.04 mm).
    c. Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.
2. Stainless-Steel Finishes:
    a. Floor Plate Finish: Mill **OR** Abrasive blasted, **as directed**.
    b. Grab Rail Finish: As selected from manufacturer's full range **OR** Directional satin finish No. 4, **as directed**.
3. Aluminum Finishes:
    a. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm **OR** AA-M12C22A31, Class II, 0.010 mm, **as directed**, or thicker.
    b. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm **OR** AA-M12C22A32/A34, Class II, 0.010 mm, **as directed**, or thicker.
        1) Color: As selected from full range of industry colors and color densities.

c. Powder-Coat Finish: Immediately after cleaning and pretreating, apply manufacturer's standard, thermosetting polyester or acrylic urethane powder coating with a cured film thickness not less than 1.5 mils (0.04 mm).
   1) Color and Gloss: As selected from manufacturer's full range.

4. Wood Finish:
   a. As specified in Division 09 Section "Wood Stains And Transparent Finishes".
      OR
      As selected from manufacturer's full range, as follows:
      1) Type: Transparent finish **OR** Transparent finish over stain, **as directed**, over wood variety indicated.
5. Fiberglass Color and Gloss: As selected from manufacturer's full range.

1.3 EXECUTION

A. Installation
1. Wiring Method: Conceal conductors and cables within housings of units or building construction. Do not install conduit exposed to view in finished spaces. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
2. Coordinate runway doors with platform travel and positioning, for accurate alignment and minimum clearance between platforms, runway doors, sills, and door frames.
3. Position sills accurately and fill space under sills solidly with nonshrink, nonmetallic grout.
4. Coordinate platform doors with platform travel and positioning.
5. Adjust stops for accurate stopping and leveling at each landing, within required tolerances.
   a. Leveling Tolerance: 1/4 inch (6 mm) up or down, regardless of load and direction of travel.
6. Adjust retractable ramps to meet maximum allowable slope and change-in-elevation requirements, and to lie fully against landing surfaces.
7. Lubricate operating parts of lift, including drive mechanism, guide rails, hinges, safety devices, and hardware.
8. Test safety devices and verify smoothness of required protective enclosures and fascias

B. Field Quality Control
1. Acceptance Testing: On completion of lift installation and before permitting use of lifts, perform acceptance tests as required and recommended by ASME A18.1 and authorities having jurisdiction.
2. Operating Test: In addition to above testing, load lifts to rated capacity and operate continuously for 30 minutes between lowest and highest landings served. Readjust stops, signal equipment, and other devices for accurate stopping and operation of system.
3. Advise Owner, Architect, and authorities having jurisdiction in advance of dates and times tests are to be performed on lifts.

C. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lifts. Include a review of emergency systems and emergency procedures to be followed at time of operational failure and other building emergencies.

END OF SECTION 14420

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NEW YORK CITY DEPARTMENT OF DESIGN + CONSTRUCTION

JOB ORDER CONTRACT

Technical Specifications

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SECTION 15041 - SEQUENCE OF OPERATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for sequence of operation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes control sequences for HVAC systems, subsystems, and equipment.

C. Definitions
1. DDC: Direct digital control.
2. VAV: Variable air volume.

D. Heating Control Sequences
1. Heating-Water Supply Temperature Control:
a. Input Device: Thermostat **OR** Thermistor temperature sensor **OR** Resistance temperature sensor, **as directed**.
b. Output Device: Control valve.
c. Action: Modulate control valve to maintain heating-water supply temperature.
d. Display:
1) Heating-water supply temperature.
2) Heating-water supply temperature set point.
3) Control-valve position.
2. Heating-Water Supply Temperature Reset:
a. Input Device: Electric, outdoor-air-reset controller **OR** Outdoor-air sensor, **as directed**.
b. Output Device: Unitary controller **OR** DDC system software, **as directed**.
c. Action: Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
1) 195 deg F (90 deg C) heating water when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
2) 130 deg F (54 deg C) heating water when outdoor-air temperature is 75 deg F (24 deg C).
3) 150 deg F (65 deg C) minimum, heating-water temperature.
d. Display:
1) Outdoor-air temperature.
2) Heating-water supply temperature.
3) Heating-water supply temperature set point.
3. Control Primary Circulating Pump(s):
a. Input Device: Thermostat **OR** DDC system, **as directed**.
b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
c. Action: Energize pump(s) at outdoor-air temperatures below 65 deg F (18 deg C).
d. Display:
1) Outdoor-air temperature.
2) Operating status of primary circulating pump(s).

E. Central Refrigeration Equipment Sequences
1. Start and Stop Condenser-Water Pump(s):
a. Enable: Allow pump to start when water is in cooling tower:
1) Input Device: Water pressure transducer.

2) Output Device: Hard wired through motor starter; DDC system binary output, **as directed**.
3) Action: Confirm water in cooling-tower sump.

b. Enable: When outdoor-air temperature conditions are met:
1) Input Device: Space thermostat **OR** DDC system outdoor-air temperature, **as directed**.
2) Output Device: Hard wired through motor starter; DDC system binary output, **as directed**.
3) Action: Confirm outdoor-air temperature is above 50 deg F (10 deg C).

c. Enable: When demand conditions are met:
1) Input Device: DDC system software demand.
2) Action: Confirm cooling demand from ventilation system(s).

d. Initiate:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**.
3) Action: Energize pump(s).

e. Display:
1) Low-level cooling-tower sump alarm.
2) Outdoor-air temperature.
3) Cooling (software) demand indication.
4) Time and time schedule.
5) Condenser-water pump(s) on-off status.
6) Condenser-water pump(s) on-off indication.

2. Start and Stop Chilled-Water Pump(s):
a. Input Device: Flow switch in condenser-water circuit.
b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
c. Action: Energize pump(s).
d. Display:
1) Chilled-water flow indication.
2) Chilled-water pump(s) on-off status.
3) Chilled-water pump(s) on-off indication.

3. Start and Stop Cooling-Tower Fans(s):
a. Input Device: Flow switch in condenser-water circuit.
b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
c. Action: Energize fan(s).
d. Display:
1) Condenser-water flow indication.
2) Cooling-tower fan(s) on-off indication.

4. Start and Stop Refrigeration Machine(s):
a. Input Device: Flow switch in condenser-water circuit. Flow switch in chilled-water circuit, **as directed**.
b. Output Device: Refrigeration **OR** DDC system command to refrigeration, **as directed**, machine terminal strip.
c. Action: Energize refrigeration machine(s) internal control circuit.
d. Display:

e. Condenser-water flow indication.
f. Chilled-water flow indication.
g. Refrigeration machine on-off indication.
h. Chilled-water supply and return temperature.
i. Chilled-water temperature control-point adjustment.

5. Start and Stop Chiller(s):
a. Input Device: Flow switches in condenser-water and chilled-water circuit.
b. Output Device: Chiller **OR** DDC system command to chiller, **as directed**, terminal strip.
c. Action: Energize chiller internal control circuit.

d. Display:
   1) Condenser-water flow indication.
   2) Chilled-water flow indication.
   3) Chiller(s) on-off status.
   4) Chiller(s) on-off indication.
   5) Chilled-water supply and return temperature.
   6) Chilled-water temperature control-point adjustment.

6. Alternate Chiller(s):
   a. Input Device: Electric alternator **OR** DDC system software, **as directed**.
   b. Output Device: Chiller **OR** DDC system command to chiller, **as directed**, terminal strip.
   c. Action: Operate chiller(s) on lead-lag, alternating each startup.
      OR
      Action: Adding and dropping chiller(s) as follows: <**Insert sequence and parameters**.>
   d. Display: Chiller(s) on-off indication.
7. Alarm Chiller(s) Start Failure:
   a. Input Device: Chiller control panel terminal strip contact **OR** software signal, **as directed**.
   b. Output Device: Analog control panel **OR** DDC system alarm, **as directed**.
   c. Action: Signal alarm.
   d. Display: Chiller "failure-to-start" indication.
8. Chilled-Water Level:
   a. Input Device: Expansion tank level switch **OR** liquid sensor, **as directed**.
   b. Output Device: Electric relay signal to alarm panel **OR** DDC system alarm, **as directed**.
   c. Action: Signal alarm.
   d. Display: Expansion tank low-level alarm.
9. Chilled-Water Supply Temperature:
   a. Input Device: Temperature sensor **OR** transmitter, **as directed**, in common chilled-water supply piping.
   b. Output Device: Integral chiller controls **OR** DDC system signal to chiller control panel, **as directed**.
   c. Action: Maintain constant leaving chilled-water temperature reset according to highest cooling demand, **as directed**.
      1) Display: Chilled-water supply temperature.
10. Condenser-Water Temperature:
   a. Input Device: Temperature sensor **OR** transmitter, **as directed**, in cooling-tower sump.
   b. Output Device: Bypass control valve **OR** Cooling-tower fan starter relay **OR** DDC system command to cooling-tower fan starter relay, **as directed**.
   c. Action: Modulate control valve open to cooling tower and closed to bypass and cycle tower fan(s) on and off **OR** and to low speed and then to high speed, **as directed**, to maintain 65 deg F (18 deg C) **OR** 70 deg F (21 deg C), **as directed**, sump temperature. Close valve when unoccupied, **as directed**.
   d. Display:
      1) Condenser-water sump (return) control-point temperature.
      2) Condenser-water sump (return) temperature.
      3) Control-valve position.
      4) Cooling-tower fan(s) on-off indication.
      5) Condenser-water supply temperature.
11. Cooling-Tower Sump Heater:
   a. Input Device: Sump temperature sensor **OR** transmitter, **as directed**.
   b. Output Device: Electric relay **OR** DDC system command to electric relay**,** as directed**,** and solenoid valve, **as directed**.
   c. Action: Energize sump heater; drain sump on low temperature, **as directed**.
   d. Display:
      1) Cooling-tower sump temperature.
      2) Cooling-tower sump heater on-off indication.
      3) Cooling-tower dump indication.
12. Operator Station Display: Indicate the following on operator workstation display terminal:

a. DDC system graphic.
b. DDC system status, on-off.
c. Low-level cooling-tower sump alarm.
d. Outdoor-air temperature.
e. Cooling (software) demand indication.
f. Time and time schedule.
g. Condenser-water pump(s) on-off status.
h. Condenser-water pump(s) on-off indication.
i. Condenser-water flow indication.
j. Chilled-water pump(s) on-off status.
k. Chilled-water pump(s) on-off indication.
l. Cooling-tower fan(s) on-off indication.
m. Chilled-water flow indication.
n. Refrigeration machine on-off indication.
o. Chilled-water supply temperature.
p. Chilled-water return temperature.
q. Chilled-water temperature control-point adjustment.
r. Chiller(s) on-off status.
s. Chiller(s) on-off indication.
t. Chiller "failure-to-start" indication.
u. Expansion tank low-level alarm.
v. Condenser-water sump (return) control-point temperature.
w. Condenser-water sump (return) temperature.
x. Condenser-water control-valve position.
y. Cooling-tower fan(s) on-off indication.
z. Condenser-water supply temperature.
aa. Cooling-tower sump temperature.
bb. Cooling-tower sump heater on-off indication.
cc. Cooling-tower dump indication.
dd. Chilled-water pressure drop through chiller.
ee. Entering condenser-water temperature.
ff. Leaving condenser-water temperature.
gg. Condenser-water pressure drop through chiller.
hh. Chiller condenser-water supply and return temperature.
ii. Chiller chilled-water supply and return temperature.
jj. System capacity in tons.

F. Air-Handling-Unit Control Sequences
1. Start and Stop Supply Fan(s):
a. Enable: Freeze Protection:
1) Input Device: Duct-mounted averaging element thermostat, located before supply fan.
2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
3) Action: Allow start if duct temperature is above 37 deg F (3 deg C); signal alarm if fan fails to start as commanded.
b. Enable: High-Temperature Protection:
1) Input Device: Duct-mounted thermostat, located in return air.
2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
3) Action: Allow start if duct temperature is below 300 deg F (150 deg C).
c. Enable: Smoke Control:
1) Input Device: Duct-mounted smoke detector, located in return **OR** supply, **as directed**, air.

2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
3) Action: Allow start if duct is free of products of combustion.

d. Initiate: Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
3) Action: Energize fan(s).

e. Initiate: Unoccupied Time Schedule:
1) Input Device: Room thermostat **OR** DDC system demand, **as directed**.
2) Output Device: Room thermostat **OR** Binary output, **as directed**, to motor starter.
3) Action: Energize fan(s).

f. Unoccupied Ventilation:
1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**, to motor starter.
3) Action: Cycle fan(s) during unoccupied periods.

g. Display: Supply-fan on-off indication.

2. Supply Fan(s) Variable-Volume Control:

a. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**.
3) Action: Enable control.

b. Volume Control (for fans equipped with variable inlet vanes):
1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing supply-duct static pressure referenced to conditioned-space static pressure.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
3) Action: Maintain constant supply-duct static pressure.

c. Volume Control (for fans equipped with variable-speed drives):
1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing supply-duct static pressure referenced to conditioned-space static pressure.
2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
3) Action: Maintain constant supply-duct static pressure.

d. High Pressure:
1) Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
2) Output Device: Receiver controller **OR** DDC system binary output, **as directed**, to alarm panel **OR** motor starter, **as directed**.
3) Action: Stop fan and signal alarm when static pressure rises above excessive-static-pressure set point.

e. Display:
1) Supply-fan-discharge static-pressure indication.
2) Supply-fan-discharge static-pressure set point.
3) Supply-fan airflow rate.
4) Supply-fan inlet vane position **OR** speed, **as directed**.

3. Start and Stop Return Fan(s):

a. Initiate: Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.

3) Action: Energize fans when supply fans are energized.

b. Initiate: Unoccupied Time Schedule:
   1) Input Device: Room thermostat **OR** DDC system demand, **as directed**.
   2) Output Device: Room thermostat **OR** Binary output, **as directed**, to motor starter.
   3) Action: Energize fans when supply fans are energized.

c. Unoccupied Ventilation:
   1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
   2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**, to motor starter.
   3) Action: Cycle fan(s) during unoccupied periods.

d. Display: Return-fan on-off indication.

4. Return Fan(s) Variable-Volume Control:
   a. Occupied Time Schedule:
      1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
      2) Output Device: Time clock **OR** Binary output, **as directed**.
      3) Action: Enable control.
   b. Volume Control (for fans equipped with variable inlet vanes):
      1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
      2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
      3) Action: Maintain constant building static pressure.
   c. Volume Control (for fans equipped with variable-speed drives):
      1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
      2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
      3) Action: Maintain constant building static pressure.
   d. Display:
      1) Return-air static-pressure indication.
      2) Return-air static-pressure set point.
      3) Return-fan airflow rate.
      4) Return-fan inlet vane position **OR** speed, **as directed**.
      5) Building static-pressure indication.
      6) Building static-pressure set point.

5. Return Fan(s) Variable-Volume Control:
   a. Occupied Time Schedule:
      1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
      2) Output Device: Time clock **OR** Binary output, **as directed**.
      3) Action: Enable control.
   b. Volume Control (for fans equipped with variable inlet vanes):
      1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
      2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
      3) Action: Maintain constant building static pressure.
   c. Volume Control (for fans equipped with variable-speed drives):
      1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.

2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
3) Action: Maintain constant building static pressure.

d. Display:
1) Return-fan-discharge static-pressure indication.
2) Return-fan-discharge static-pressure set point.
3) Return-fan airflow rate.
4) Return-fan inlet vane position **OR** speed, **as directed**.

6. Preheat Coil:
a. Freeze Protection:
1) Input Device: Duct-mounted averaging element thermostat, located after preheat coil.
2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
3) Action: Allow start if duct temperature is above 33 deg F (1 deg C).

b. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
3) Action: Energize coil circulating pump(s).

c. Supply **OR** Discharge, **as directed**,-Air Temperature:
1) Input Device: Time clock and duct-mounted thermostat **OR** DDC system time schedule and electronic temperature sensor, **as directed**.
2) Output Device: Modulating control valve.
3) Action: Maintain air temperature set point of 55 deg F (13 deg C).

d. Unoccupied Time Schedule:
1) Input Device: Time clock and duct-mounted thermostat mounted in outdoor air **OR** DDC system time schedule and outdoor-air temperature, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
3) Action: Energize coil circulating pump(s) when outdoor-air temperature falls below 35 deg F (2 deg C).

e. Display:
1) Preheat-coil air-temperature indication.
2) Preheat-coil air-temperature set point.
3) Preheat-coil pump operation indication.
4) Preheat-coil control-valve position.

7. Mixed-Air Control:
a. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Pneumatic relay **OR** DDC system output, **as directed**.
3) Action: Enable control.

b. Minimum Position:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
3) Action: Open minimum outdoor-air dampers **OR** outdoor-air dampers to minimum position, **as directed**.

c. Heating Reset:
1) Input Device: Room thermostat **OR** DDC system software, **as directed**.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
3) Action: Close minimum outdoor-air dampers **OR** Set outdoor-air dampers to minimum position, **as directed**.

d. Supply **OR** Mixed, **as directed**,-Air Temperature:

1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
3) Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of 55 deg F (13 deg C).

e. Cooling Reset:
1) Input Device: Outdoor- and return-air, duct-mounted thermostats **OR** electronic temperature sensors, **as directed**.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to damper actuator(s).
3) Action: Set outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature **OR** enthalpy exceeds return-air enthalpy, **as directed**.

f. Unoccupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
3) Action: Position outdoor- and relief-air dampers closed and return-air dampers open.

g. Display:
1) Mixed-air-temperature indication.
2) Mixed-air-temperature set point.
3) Mixed-air damper position.

8. Humidifier:
a. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**, and airflow switch
2) Output Device: Pneumatic relay **OR** DDC system output, **as directed**.
3) Action: Enable control.

b. Humidity:
1) Input Device: Room humidistat **OR** Return-air, duct-mounted humidistat **OR** DDC system, **as directed**.
2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, enables humidifier **OR** modulates control valve to maintain humidity **OR** cycles pump to maintain humidity **OR** cycles pump and modulates control valve to maintain humidity, **as directed**, in straight-line relationship for the following conditions:
a) 20 percent when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
b) 40 percent when outdoor-air temperature is 75 deg F (24 deg C).
3) Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of 55 deg F (13 deg C).

c. Display:
1) Relative humidity indication.
2) Relative humidity set point.
3) Relative humidity control-valve position.

9. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.
a. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Electric relay **OR** DDC system output, **as directed**.
3) Action: Enable control.

b. Differential Pressure:

1) Input Device: Differential-pressure switches **OR** Pressure transmitter, **as directed**.
2) Output Device: Analog alarm panel **OR** DDC system alarm, **as directed**.
3) Action: Signal alarm on low- and high-pressure conditions.

c. Display:
1) Filter air-pressure-drop indication.
2) Filter low-air-pressure set point.
3) Filter high-air-pressure set point.

10. Hydronic **OR** Steam, **as directed**, Heating Coil:
a. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**.
3) Action: Enable control.

b. Supply **OR** Discharge, **as directed**,-Air Temperature:
1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Normally open **OR** closed, **as directed**, modulating control valve.
3) Action: Maintain supply-air temperature set point of 55 deg F (13 deg C).

c. Temperature Reset (for constant-temperature supply-air systems):
1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**, in return air.
2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**, in straight-line relationship for the following conditions:
a) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
b) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).
3) Action: Reset supply-air temperature set point of 55 deg F (13 deg C).

d. Temperature Reset (for multizone or dual-duct supply-air systems):
1) Input Device: Load analyzer **OR** DDC system, **as directed**, with input from room thermostats **OR** temperature sensors, **as directed**.
2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**.
3) Action: Reset supply-air temperature in response to greatest heating demand.

e. Unoccupied Time Schedule:
1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
2) Output Device: Room thermostat (cycling fan) **OR** DDC system binary output, **as directed**.
3) Action: Enable normal control **OR** Return valve to normal position, **as directed**, when fan is cycled on.

f. Display:
1) Fan-discharge air-temperature indication.
2) Fan-discharge air-temperature set point.
3) Heating-coil air-temperature indication.
4) Heating-coil air-temperature set point.
5) Heating-coil pump operation indication.
6) Heating-coil control-valve position.
7) Hot-deck air-temperature indication.
8) Hot-deck air-temperature set point.

11. Hydronic Cooling Coil:
a. Occupied Time Schedule:
1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**.
3) Action: Enable control.

b. Supply **OR** Discharge, **as directed**,-Air Temperature:
1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Normally open **OR** closed, **as directed**, modulating control valve.
3) Action: Maintain supply-air temperature set point of 55 deg F (13 deg C).

c. Temperature Reset (for constant-temperature systems):
   1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**, in return air.
   2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**, in straight-line relationship for the following conditions:
      a) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
      b) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).
   3) Action: Reset supply-air temperature set point of 55 deg F (13 deg C).

d. Temperature Reset (for multizone or dual-duct supply-air systems):
   1) Input Device: Load analyzer **OR** DDC system, **as directed**, with input from room thermostats **OR** temperature sensors, **as directed**.
   2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**.
   3) Action: Reset supply-air temperature in response to greatest heating demand.

e. Unoccupied Time Schedule:
   1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
   2) Output Device: Time clock **OR** Binary output, **as directed**.
   3) Action: Disable control.

f. Display:
   1) Fan-discharge air-temperature indication.
   2) Fan-discharge air-temperature set point.
   3) Cooling-coil air-temperature indication.
   4) Cooling-coil air-temperature set point.
   5) Cooling-coil control-valve position.
   6) Cold-deck air-temperature indication.
   7) Cold-deck air-temperature set point.

12. Multizone Damper Control:
   a. Occupied Time Schedule:
      1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
      2) Output Device: Time clock **OR** Binary output, **as directed**.
      3) Action: Enable control.
   b. Room Temperature:
      1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
      2) Output Device: Damper actuator.
      3) Action: Maintain room temperature.
   c. Display:
      1) Room temperature indication.
      2) Room temperature set point.
      3) Multizone damper position.

13. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

14. Operator Station Display: Indicate the following on operator workstation display terminal:
   a. DDC system graphic.
   b. DDC system on-off indication.
   c. DDC system occupied/unoccupied mode.
   d. Outdoor-air-temperature indication.
   e. Supply-fan on-off indication.
   f. Supply-fan-discharge static-pressure indication.
   g. Supply-fan-discharge static-pressure set point.
   h. Supply-fan airflow rate.
   i. Supply-fan inlet vane position **OR** speed, **as directed**.
   j. Return-fan on-off indication.
   k. Return-air static-pressure indication.
   l. Return-air static-pressure set point.
   m. Return-fan airflow rate.
   n. Return-fan inlet vane position **OR** speed, **as directed**.

o. Building static-pressure indication.
p. Building static-pressure set point.
q. Preheat-coil air-temperature indication.
r. Preheat-coil air-temperature set point.
s. Preheat-coil pump operation indication.
t. Preheat-coil control-valve position.
u. Mixed-air-temperature indication.
v. Mixed-air-temperature set point.
w. Mixed-air damper position.
x. Relative humidity indication.
y. Relative humidity set point.
z. Relative humidity control-valve position.
aa. Filter air-pressure-drop indication.
bb. Filter low-air-pressure set point.
cc. Filter high-air-pressure set point.
dd. Fan-discharge air-temperature indication.
ee. Fan-discharge air-temperature set point.
ff. Heating-coil air-temperature indication.
gg. Heating-coil air-temperature set point.
hh. Heating-coil pump operation indication.
ii. Heating-coil control-valve position.
jj. Hot-deck air-temperature indication.
kk. Hot-deck air-temperature set point.
ll. Cooling-coil air-temperature indication.
mm. Cooling-coil air-temperature set point.
nn. Cooling-coil control-valve position.
oo. Cold-deck air-temperature indication.
pp. Cold-deck air-temperature set point.
qq. Room temperature indication.
rr. Room temperature set point.
ss. Multizone damper position.

G. Terminal Unit Operating Sequence
1. Cabinet Unit Heater, Hydronic **OR** Steam, **as directed**:
a. Room Temperature:
1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**.
3) Action: Cycle fan to maintain temperature.
b. Low-Temperature Safety:
1) Input Device: Line-voltage, on-off thermostat, pipe mounted.
2) Output Device: Hard wired.
3) Action: Stop fan when return heating-water **OR** condensate, **as directed**, temperature falls below 35 deg F (2 deg C).
c. Display:
1) Room temperature indication.
2) Room temperature set point.
2. Cabinet Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.
3. Unit Heater, Hydronic **OR** Steam, **as directed**:
a. Room Temperature:
1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**.
3) Action: Cycle fan to maintain temperature.
b. Low-Temperature Safety:
1) Input Device: Line-voltage, on-off thermostat, pipe mounted.
2) Output Device: Hard wired.

3) Action: Stop fan when return heating-water **OR** condensate, **as directed**, temperature falls below 35 deg F (2 deg C).

c. Display:
1) Room temperature indication.
2) Room temperature set point.

4. Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.
5. Combustion-Air Unit Heaters:
a. Room Temperature:
1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
3) Action: Modulate valve to maintain temperature.
b. Display:
1) Room temperature indication.
2) Room temperature set point.
3) Control-valve position.
6. Radiant Heating Cable, Electric: Room thermostat cycles power.
7. Radiant Heating Panel, Electric: Room thermostat cycles power.
8. Radiant Heating Panel, Hydronic:
a. Room Temperature:
1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
3) Action: Modulate valve to maintain temperature.
b. Display:
1) Room temperature indication.
2) Room temperature set point.
3) Control-valve position.
9. Two-Pipe, Single-Coil, Fan-Coil Unit:
a. Occupied Time Schedule:
1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**.
3) Action: Start and stop fan and enable control.
b. Room Temperature:
1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**, in room **OR** return air, **as directed**.
2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
3) Action: Modulate valve to maintain temperature.
c. DDC System Changeover:
1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in supply-water **OR** on supply-water piping **OR** DDC system, **as directed**.
2) Output Device: Hard-wired relay **OR** DDC system software, **as directed**.
3) Action: Reverse control-valve action to switch from heating to cooling.
d. Display:
1) DDC system graphic.
2) DDC system on-off indication.
3) DDC system occupied/unoccupied mode.
4) Room temperature indication.
5) Room temperature set point.
6) Control-valve position.
7) Supply-water temperature indication.
10. Four-Pipe, Hydronic Fan-Coil Unit:
a. Occupied Time Schedule:
1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
2) Output Device: Time clock **OR** Binary output, **as directed**.

3) Action: Start and stop fan, and enable control.

b. Room Temperature:
   1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
   2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators.
   3) Action: Modulate multiport control valves to maintain temperature.

c. Display:
   1) DDC system graphic.
   2) DDC system on-off indication.
   3) DDC system occupied/unoccupied mode.
   4) Room temperature indication.
   5) Room temperature set point.
   6) Control-valve position.

11. Unit Ventilator: Room thermostat modulates heating-and-cooling control valves; airstream thermostats modulate outdoor- and return-air dampers as follows:

a. Occupied Time Schedule:
   1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
   2) Output Device: Time clock **OR** Binary output, **as directed**.
   3) Action: Start and stop fan, move outdoor- and return-air dampers to minimum **OR** maximum, **as directed**, outdoor-air position, and enable control.

b. Room Temperature - Valves:
   1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
   2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators.
   3) Action: Modulate heating-water supply control valve and chilled-water supply control valve in sequence to maintain temperature.

c. Room Temperature - Dampers:
   1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in mixed air.
   2) Output Device: Pneumatic **OR** Electronic, **as directed**, control damper actuators.
   3) Action: Modulate outdoor- and return-air dampers to maintain temperature.

d. Supply-Air Temperature Limit:
   1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in discharge air.
   2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators and control damper actuators.
   3) Action: Override room thermostat to control valves and dampers to prevent discharge air from dropping below a minimum set point.

e. Warm-up Cycle:
   1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
   2) Output Device: Hard-wired relay **OR** DDC system binary output, **as directed**.
   3) Action: Open heating-water supply control valve, close outdoor-air damper, and open return-air damper.

f. Display:
   1) DDC system graphic.
   2) DDC system on-off indication.
   3) DDC system occupied/unoccupied mode.
   4) Room temperature indication.
   5) Room temperature set point.
   6) Control-valve position.
   7) Damper position.

12. Heating Coils, Hydronic **OR** Steam, **as directed**:

a. Room Temperature:
   1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
   2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
   3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.

b. Display:
   1) Room temperature indication.
   2) Room temperature set point.
   3) Control-valve position.

13. Heating Coils, Electric: Room thermostat cycles coils **OR** sequences stages of heating, **as directed**.
14. Radiators and Convectors, Hydronic **OR** Steam, **as directed**:
    a. Occupancy:
       1) Input Device: Occupancy sensor.
       2) Output Device: DDC system binary output.
       3) Action: Report occupancy and enable occupied temperature set point.
    b. Room Temperature:
       1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
       2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
       3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.
          a) Occupied Temperature: 75 deg F (24 deg C).
          b) Unoccupied Temperature: 65 deg F (18 deg C).
    c. Display:
       1) Room/area served.
       2) Room temperature indication.
       3) Room temperature set point.
       4) Room temperature set point, occupied.
       5) Room temperature set point, occupied standby.
       6) Room temperature set point, unoccupied.
       7) Control-valve position as percent open.
15. Radiators and Convectors, Electric: Room thermostat cycles coils **OR** sequences stages of heating, **as directed**.
16. Constant-Volume, Terminal Air Units, Hydronic **OR** Steam, **as directed**:
    a. Occupancy:
       1) Input Device: Occupancy sensor.
       2) Output Device: DDC system binary output.
       3) Action: Report occupancy and enable occupied temperature set point.
          a) Occupied Temperature: 75 deg F (24 deg C).
          b) Unoccupied Temperature: 65 deg F (18 deg C).
    b. Room Temperature:
       1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
       2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
       3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.
    c. Display:
       1) Room/area served.
       2) Room occupied/unoccupied.
       3) Room temperature indication.
       4) Room temperature set point.
       5) Room temperature set point, occupied.
       6) Room temperature set point, unoccupied.
       7) Control-valve position as percent open.
17. VAV, Terminal Air Units with Hydronic **OR** Steam, **as directed**, Coils:
    a. Occupancy:
       1) Input Device: Occupancy sensor.
       2) Output Device: DDC system binary output.
       3) Action: Report occupancy and enable occupied temperature set point.
          a) Occupied Temperature: 75 deg F (24 deg C).
          b) Unoccupied Temperature: 65 deg F (18 deg C).

b. Room Temperature:
   1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
   2) Output Device: Pneumatic **OR** Electronic, **as directed**, damper actuators and control-valve operators.
   3) Action: Modulate damper and valve to maintain temperature.
      a) Sequence damper from full open to minimum position, then valve from closed to fully open.

c. Display:
   1) Room/area served.
   2) Room occupied/unoccupied.
   3) Room temperature indication.
   4) Room temperature set point.
   5) Room temperature set point, occupied.
   6) Room temperature set point, unoccupied.
   7) Air-damper position as percent open.
   8) Control-valve position as percent open.

18. Dual-Duct, VAV, Terminal Air Units:

a. Occupancy:
   1) Input Device: Occupancy sensor.
   2) Output Device: DDC system binary output.
   3) Action: Report occupancy and enable occupied temperature set point.
      a) Occupied Temperature: 75 deg F (24 deg C).
      b) Unoccupied Temperature: 65 deg F (18 deg C).

b. Room Temperature:
   1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
   2) Output Device: Pneumatic **OR** Electronic, **as directed**, damper actuators.
   3) Action: Modulate dampers to maintain temperature.
      a) Sequence when space temperature is below set point: Close VAV damper to minimum position, open hot-deck dampers and close cold-deck dampers, then open VAV damper.
      b) Sequence when space temperature is above set point: Close VAV damper to minimum position, close hot-deck dampers and open cold-deck dampers, then open VAV damper.

c. Display:
   1) Room/area served.
   2) Room occupied/unoccupied.
   3) Room temperature indication.
   4) Room temperature set point.
   5) Room temperature set point, occupied.
   6) Room temperature set point, unoccupied.
   7) VAV damper position as percent open.
   8) Hot-deck damper position as percent open.
   9) Cold-deck damper position as percent open.

H. Ventilation Sequences

1. Combustion-Air, Makeup Unit Control, Electric: Start fan when served appliance burner starts; room thermostat sequences stages of heating.
2. Combustion-Air, Makeup Unit Control, Hydronic **OR** Steam, **as directed**: Start fan when served appliance burner starts; room thermostat cycles **OR** modulates, **as directed**, control valve.
3. Gravity Roof Ventilator: Occupancy sensor **OR** Room thermostat, **as directed**, opens dampers.
4. Exhaust Fan: Occupancy sensor **OR** Interlock with light switch **OR** Room thermostat, **as directed**, cycles fan.
5. Kitchen Exhaust Fan: Occupancy sensor starts fan and energizes makeup air unit.

1.2 PRODUCTS (Not Applicable)

1.3 EXECUTION (Not Applicable)

END OF SECTION 15041

SECTION 15042 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for identification for plumbing piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Equipment labels.
b. Warning signs and labels.
c. Pipe labels.
d. Stencils.
e. Valve tags.
f. Warning tags.

C. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Equipment Labels
1. Metal Labels for Equipment:
a. Material and Thickness: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
b. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
c. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
d. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
e. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
2. Plastic Labels for Equipment:
a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
b. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
c. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
d. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
e. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
f. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
g. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
h. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

3. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

B. Warning Signs And Labels
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
9. Label Content: Include caution and warning information, plus emergency notification instructions.

C. Pipe Labels
1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover **OR** cover full, **as directed,** circumference of pipe and to attach to pipe without fasteners or adhesive.
3. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
4. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   b. Lettering Size: At least 1-1/2 inches (38 mm) high.

D. Stencils
1. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
   a. Stencil Material: Aluminum **OR** Brass **OR** Fiberboard, **as directed**.
   b. Stencil Paint: Exterior, gloss, alkyd enamel **OR** acrylic enamel, **as directed**, black unless otherwise indicated. Paint may be in pressurized spray-can form.
   c. Identification Paint: Exterior, alkyd enamel **OR** acrylic enamel, **as directed**, in colors according to ASME A13.1 unless otherwise indicated.

E. Valve Tags
1. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
   a. Tag Material: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.

b. Fasteners: Brass wire-link chain **OR** beaded chain **OR** S-hook, **as directed**.

2. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   a. Valve-tag schedule shall be included in operation and maintenance data.

F. Warning Tags
1. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   a. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum **OR** Approximately 4 by 7 inches (100 by 178 mm), **as directed**.
   b. Fasteners: Brass grommet and wire **OR** Reinforced grommet and wire or string, **as directed**.
   c. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   d. Color: Yellow background with black lettering.

1.3 EXECUTION

A. Preparation
1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

B. Equipment Label Installation
1. Install or permanently fasten labels on each major item of mechanical equipment.
2. Locate equipment labels where accessible and visible.

C. Pipe Label Installation
1. Piping Color-Coding: Painting of piping is specified in Division 09 Section(s) "Interior Painting" OR "High-performance Coatings", **as directed**.
2. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles **OR** complying with ASME A13.1, **as directed**, on each piping system.
   a. Identification Paint: Use for contrasting background.
   b. Stencil Paint: Use for pipe marking.
3. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   a. Near each valve and control device.
   b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   c. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   d. At access doors, manholes, and similar access points that permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
   g. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
4. Pipe Label Color Schedule:
   a. Low-Pressure, Compressed-Air Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
   b. Medium-Pressure, Compressed-Air Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

c. Domestic Water Piping:

1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

d. Sanitary Waste and Storm Drainage Piping:

1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

D. Valve-Tag Installation

1. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

2. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

a. Valve-Tag Size and Shape:

1) Cold Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.

2) Hot Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.

3) Low-Pressure Compressed Air: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.

4) High-Pressure Compressed Air: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.

b. Valve-Tag Color:

1) Cold Water: Natural **OR** Green, **as directed**.

2) Hot Water: Natural **OR** Green, **as directed**.

3) Low-Pressure Compressed Air: Natural **OR** Green, **as directed**.

4) High-Pressure Compressed Air: Natural **OR** Green, **as directed**.

c. Letter Color:

1) Cold Water: Black **OR** White, **as directed**.

2) Hot Water: Black **OR** White, **as directed**.

3) Low-Pressure Compressed Air: Black **OR** White, **as directed**.

4) High-Pressure Compressed Air: Black **OR** White, **as directed**.

E. Warning-Tag Installation

1. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15042

SECTION 15042a - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for identification for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Equipment labels.
b. Warning signs and labels.
c. Pipe labels.
d. Duct labels.
e. Stencils.
f. Valve tags.
g. Warning tags.

C. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Equipment Labels
1. Metal Labels for Equipment:
a. Material and Thickness: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
b. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
c. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
d. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
e. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
2. Plastic Labels for Equipment:
a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
b. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
c. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
d. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
e. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
f. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
g. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.

h. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

3. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
4. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

B. Warning Signs And Labels

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
9. Label Content: Include caution and warning information, plus emergency notification instructions.

C. Pipe Labels

1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover **OR** cover full, **as directed**, circumference of pipe and to attach to pipe without fasteners or adhesive.
3. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
4. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
   a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   b. Lettering Size: At least 1-1/2 inches (38 mm) high.

D. Duct Labels

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) **OR** 1/8 inch (3.2 mm), **as directed**, thick, and having predrilled holes for attachment hardware.
2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
4. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

9. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
   a. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   b. Lettering Size: At least 1-1/2 inches (38 mm) high.

E. Stencils
1. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
   a. Stencil Material: Aluminum **OR** Brass **OR** Fiberboard, **as directed**.
   b. Stencil Paint: Exterior, gloss, alkyd enamel **OR** acrylic enamel, **as directed**, black unless otherwise indicated. Paint may be in pressurized spray-can form.
   c. Identification Paint: Exterior, alkyd enamel **OR** acrylic enamel, **as directed**, in colors according to ASME A13.1 unless otherwise indicated.

F. Valve Tags
1. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
   a. Tag Material: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
   b. Fasteners: Brass wire-link chain **OR** beaded chain **OR** S-hook, **as directed**.
2. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
   a. Valve-tag schedule shall be included in operation and maintenance data.

G. Warning Tags
1. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   a. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum **OR** Approximately 4 by 7 inches (100 by 178 mm), **as directed**.
   b. Fasteners: Brass grommet and wire **OR** Reinforced grommet and wire or string, **as directed**.
   c. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   d. Color: Yellow background with black lettering.

1.3 EXECUTION

A. Preparation
1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

B. Equipment Label Installation
1. Install or permanently fasten labels on each major item of mechanical equipment.
2. Locate equipment labels where accessible and visible.

C. Pipe Label Installation
1. Piping Color-Coding: Painting of piping is specified in Division 09 Section(s) "Interior Painting" OR "High-performance Coatings", **as directed**.

2. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles **OR** complying with ASME A13.1**, as directed**, on each piping system.
   a. Identification Paint: Use for contrasting background.
   b. Stencil Paint: Use for pipe marking.
3. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   a. Near each valve and control device.
   b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   c. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   d. At access doors, manholes, and similar access points that permit view of concealed piping.
   e. Near major equipment items and other points of origination and termination.
   f. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
   g. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
4. Pipe Label Color Schedule:
   a. Chilled-Water Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
   b. Condenser-Water Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **asa directed**.
   c. Heating Water Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
   d. Refrigerant Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
   e. Low-Pressure Steam Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
   f. High-Pressure Steam Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
   g. Steam Condensate Piping:
      1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
      2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

D. Duct Label Installation
1. Install plastic-laminated **OR** self-adhesive, **as directed**, duct labels with permanent adhesive on air ducts in the following color codes:
   a. Blue: For cold-air supply ducts.
   b. Yellow: For hot-air supply ducts.
   c. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
   d. ASME A13.1 Colors and Designs: For hazardous material exhaust.
2. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
3. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

E. Valve-Tag Installation
   1. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
   2. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
      a. Valve-Tag Size and Shape:
         1) Chilled Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         2) Condenser Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         3) Refrigerant: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         4) Hot Water: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         5) Gas: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         6) Low-Pressure Steam: 1-1/2 inches (38 mm)2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         7) High-Pressure Steam: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
         8) Steam Condensate: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, round **OR** square, **as directed**.
      b. Valve-Tag Color:
         1) Chilled Water: Natural **OR** Green, **as directed.**
         2) Condenser Water: Natural **OR** Green, **as directed.**
         3) Refrigerant: Natural **OR** Green, **as directed**.
         4) Hot Water: Natural **OR** Green, **as directed**.
         5) Gas: Natural **OR** Yellow, **as directed**.
         6) Low-Pressure Steam: Natural **OR** Yellow, **as directed**.
         7) High-Pressure Steam: Natural **OR** Green, **as directed**.
         8) Steam Condensate: Natural **OR** Green, **as directed**.
      c. Letter Color:
         1) Chilled Water: Black **OR** White, **as directed**.
         2) Condenser Water: Black **OR** White, **as directed**.
         3) Refrigerant: Black **OR** White, **as directed**.
         4) Hot Water: Black **OR** White, **as directed**.
         5) Gas: Black **OR** White, **as directed**.
         6) Low-Pressure Steam: Black **OR** White, **as directed**.
         7) High-Pressure Steam: Black **OR** White, **as directed**.
         8) Steam Condensate: Black **OR** White, **as directed**.

F. Warning-Tag Installation
   1. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 15042a

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Task	Specification	Specification Description
15042	15041	Sequence Of Operation

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SECTION 15043 - TESTING, ADJUSTING, AND BALANCING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for testing, adjusting and balancing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Balancing Air Systems:
1) Constant-volume air systems.
2) Dual-duct systems.
3) Variable-air-volume systems.
4) Multizone systems.
5) Induction-unit systems.
b. Balancing Hydronic Piping Systems:
1) Constant-flow hydronic systems.
2) Variable-flow hydronic systems.
3) Primary-secondary hydronic systems.

C. Definitions
1. AABC: Associated Air Balance Council.
2. NEBB: National Environmental Balancing Bureau.
3. TAB: Testing, adjusting, and balancing.
4. TABB: Testing, Adjusting, and Balancing Bureau.
5. TAB Specialist: An entity engaged to perform TAB Work.

D. Submittals
1. LEED Submittal:
a. Air-Balance Report for LEED Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
2. Strategies and Procedures Plan: Within 30 **OR** 60 **OR** 90, **as directed**, days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
3. Certified TAB reports.

E. Quality Assurance
1. TAB Contractor Qualifications: Engage a TAB entity certified by AABC **OR** NEBB **OR** TABB, **as directed**.
a. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC **OR** NEBB **OR** TABB, **as directed**.
b. TAB Technician: Employee of the TAB contractor and who is certified by AABC **OR** NEBB **OR** TABB, **as directed**, as a TAB technician.
2. Certify TAB field data reports and perform the following:
a. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
b. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
3. TAB Report Forms: Use standard TAB contractor's forms approved by the Owner **OR** Owner **OR** Commissioning Authority, **as directed**.
4. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. Project Conditions

1. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

   OR

   Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.2 PRODUCTS (Not Applicable)

1.3 EXECUTION

A. Examination

1. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
2. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
3. Examine the approved submittals for HVAC systems and equipment.
4. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
5. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 15 Section(s) "Metal Ducts" OR "Nonmetal Ducts", **as directed**, and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
6. Examine equipment performance data including fan and pump curves.
   a. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
   b. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
7. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
8. Examine test reports specified in individual system and equipment Sections.
9. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
10. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
11. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
12. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
13. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
14. Examine system pumps to ensure absence of entrained air in the suction piping.
15. Examine operating safety interlocks and controls on HVAC equipment.
16. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

B. Preparation
   1. Prepare a TAB plan that includes strategies and step-by-step procedures.
   2. Complete system-readiness checks and prepare reports. Verify the following:
      a. Permanent electrical-power wiring is complete.
      b. Hydronic systems are filled, clean, and free of air.
      c. Automatic temperature-control systems are operational.
      d. Equipment and duct access doors are securely closed.
      e. Balance, smoke, and fire dampers are open.
      f. Isolating and balancing valves are open and control valves are operational.
      g. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
      h. Windows and doors can be closed so indicated conditions for system operations can be met.

C. General Procedures For Testing And Balancing
   1. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" **OR** ASHRAE 111 **OR** NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" **OR** SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", **as directed**, and in this Section.
      a. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
   2. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
      a. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
         OR
         After testing and balancing, install test ports and duct access doors that comply with requirements in Division 15 Section "Duct Accessories".
      b. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 15 Section "Hvac Insulation".
   3. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
   4. Take and report testing and balancing measurements in inch-pound (IP) **OR** metric (SI) **OR** inch-pound (IP) and metric (SI), **as directed,** units.

D. General Procedures For Balancing Air Systems
   1. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
   2. Prepare schematic diagrams of systems' "as-built" duct layouts.
   3. For variable-air-volume systems, develop a plan to simulate diversity.
   4. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
   5. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
   6. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
   7. Verify that motor starters are equipped with properly sized thermal protection.
   8. Check dampers for proper position to achieve desired airflow path.
   9. Check for airflow blockages.
   10. Check condensate drains for proper connections and functioning.
   11. Check for proper sealing of air-handling-unit components.
   12. Verify that air duct system is sealed as specified in Division 15 Section "Metal Ducts".

E. Procedures For Constant-Volume Air Systems
   1. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

a. Measure total airflow.
   1) Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
b. Measure fan static pressures as follows to determine actual static pressure:
   1) Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   2) Measure static pressure directly at the fan outlet or through the flexible connection.
   3) Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
   4) Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
c. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   1) Report the cleanliness status of filters and the time static pressures are measured.
d. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
e. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
f. Obtain approval from the Owner **OR** Owner **OR** Commissioning Authority, **as directed**, for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 15 for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
g. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.

2. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
   a. Measure airflow of submain and branch ducts.
      1) Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
   b. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
   c. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
3. Measure air outlets and inlets without making adjustments.
   a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
4. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
   a. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
   b. Adjust patterns of adjustable outlets for proper distribution without drafts.

F. Procedures For Dual-Duct Systems
   1. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.

2. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
   a. If insufficient static pressure exists, increase airflow at the fan.
3. Test and adjust the constant-volume mixing boxes as follows:
   a. Verify both hot and cold operations by adjusting the thermostat and observing changes in air temperature and volume.
   b. Verify sufficient inlet static pressure before making volume adjustments.
   c. Adjust mixing boxes to indicated airflows within specified tolerances. Measure airflow by Pitot-tube traverse readings or by measuring static pressure at mixing-box taps if provided by mixing-box manufacturer.
4. Do not overpressurize ducts.
5. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
6. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume, dual-duct systems; adjust maximum- and minimum-airflow setting of each mixing box.

G. Procedures For Variable-Air-Volume Systems
1. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   a. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
   b. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   c. Measure total system airflow. Adjust to within indicated airflow.
   d. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
   e. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
      1) If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
   f. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
      1) Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
   g. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
   h. Record final fan-performance data.
3. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   a. Balance variable-air-volume systems the same as described for constant-volume air systems.
   b. Set terminal units and supply fan at full-airflow condition.

c. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
d. Readjust fan airflow for final maximum readings.
e. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
f. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
g. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
    1) If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
h. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
    1) Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

4. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
    a. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
    b. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
    c. Set terminal units at full-airflow condition.
    d. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
    e. Adjust terminal units for minimum airflow.
    f. Measure static pressure at the sensor.
    g. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

H. Procedures For Multizone Systems
1. Set unit at maximum airflow through the cooling coil.
2. Adjust each zone's balancing damper to achieve indicated airflow within the zone.

I. Procedures For Induction-Unit Systems
1. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.
2. Adjust each induction unit.

J. General Procedures For Hydronic Systems
1. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
2. Prepare schematic diagrams of systems' "as-built" piping layouts.
3. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
    a. Open all manual valves for maximum flow.
    b. Check liquid level in expansion tank.
    c. Check makeup water-station pressure gage for adequate pressure for highest vent.

d. Check flow-control valves for specified sequence of operation, and set at indicated flow.
e. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
f. Set system controls so automatic valves are wide open to heat exchangers.
g. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
h. Check air vents for a forceful liquid flow exiting from vents when manually operated.

K. Procedures For Constant-Flow Hydronic Systems
1. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
a. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
1) If impeller sizes must be adjusted to achieve pump performance, obtain approval from the Owner **OR** Owner **OR** Commissioning Authority, **as directed**, and comply with requirements in Division 15 Section "Hydronic Pumps".
b. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
1) Monitor motor performance during procedures and do not operate motors in overload conditions.
c. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
d. Report flow rates that are not within plus or minus 10 percent of design.
2. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
3. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
4. Set calibrated balancing valves, if installed, at calculated presettings.
5. Measure flow at all stations and adjust, where necessary, to obtain first balance.
a. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
6. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
7. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
a. Determine the balancing station with the highest percentage over indicated flow.
b. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
c. Record settings and mark balancing devices.
8. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
9. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
10. Check settings and operation of each safety valve. Record settings.

L. Procedures For Variable-Flow Hydronic Systems
1. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

M. Procedures For Primary-Secondary Hydronic Systems
1. Balance the primary circuit flow first and then balance the secondary circuits.

N. Procedures For Steam Systems
   1. Measure and record upstream and downstream pressure of each piece of equipment.
   2. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
   3. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
   4. Check settings and operation of each safety valve. Record settings.
   5. Verify the operation of each steam trap.

O. Procedures For Heat Exchangers
   1. Measure water flow through all circuits.
   2. Adjust water flow to within specified tolerances.
   3. Measure inlet and outlet water temperatures.
   4. Measure inlet steam pressure.
   5. Check settings and operation of safety and relief valves. Record settings.

P. Procedures For Motors
   1. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
      a. Manufacturer's name, model number, and serial number.
      b. Motor horsepower rating.
      c. Motor rpm.
      d. Efficiency rating.
      e. Nameplate and measured voltage, each phase.
      f. Nameplate and measured amperage, each phase.
      g. Starter thermal-protection-element rating.
   2. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

Q. Procedures For Chillers
   1. Balance water flow through each evaporator and condenser, **as directed**, to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
      a. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
      b. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
      c. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
      d. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
      e. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
      f. Capacity: Calculate in tons of cooling.
      g. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

R. Procedures For Cooling Towers
   1. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
      a. Measure condenser-water flow to each cell of the cooling tower.
      b. Measure entering- and leaving-water temperatures.
      c. Measure wet- and dry-bulb temperatures of entering air.
      d. Measure wet- and dry-bulb temperatures of leaving air.
      e. Measure condenser-water flow rate recirculating through the cooling tower.

f. Measure cooling-tower spray pump discharge pressure.
g. Adjust water level and feed rate of makeup water system.
h. Measure flow through bypass.

S. Procedures For Condensing Units
1. Verify proper rotation of fans.
2. Measure entering- and leaving-air temperatures.
3. Record compressor data.

T. Procedures For Boilers
1. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
2. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.

U. Procedures For Heat-Transfer Coils
1. Measure, adjust, and record the following data for each water coil:
a. Entering- and leaving-water temperature.
b. Water flow rate.
c. Water pressure drop.
d. Dry-bulb temperature of entering and leaving air.
e. Wet-bulb temperature of entering and leaving air for cooling coils.
f. Airflow.
g. Air pressure drop.
2. Measure, adjust, and record the following data for each electric heating coil:
a. Nameplate data.
b. Airflow.
c. Entering- and leaving-air temperature at full load.
d. Voltage and amperage input of each phase at full load and at each incremental stage.
e. Calculated kilowatt at full load.
f. Fuse or circuit-breaker rating for overload protection.
3. Measure, adjust, and record the following data for each steam coil:
a. Dry-bulb temperature of entering and leaving air.
b. Airflow.
c. Air pressure drop.
d. Inlet steam pressure.
4. Measure, adjust, and record the following data for each refrigerant coil:
a. Dry-bulb temperature of entering and leaving air.
b. Wet-bulb temperature of entering and leaving air.
c. Airflow.
d. Air pressure drop.
e. Refrigerant suction pressure and temperature.

V. Procedures For Testing, Adjusting, And Balancing Existing Systems
1. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
a. Measure and record the operating speed, airflow, and static pressure of each fan.
b. Measure motor voltage and amperage. Compare the values to motor nameplate information.
c. Check the refrigerant charge.
d. Check the condition of filters.
e. Check the condition of coils.
f. Check the operation of the drain pan and condensate-drain trap.
g. Check bearings and other lubricated parts for proper lubrication.
h. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

2. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
   a. New filters are installed.
   b. Coils are clean and fins combed.
   c. Drain pans are clean.
   d. Fans are clean.
   e. Bearings and other parts are properly lubricated.
   f. Deficiencies noted in the preconstruction report are corrected.
3. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
   a. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
   b. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
   c. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
   d. Balance each air outlet.

W. Tolerances

X. Set HVAC system's air flow rates and water flow rates within the following tolerances:
   a. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
   b. Air Outlets and Inlets: Plus or minus 10 percent.
   c. Heating-Water Flow Rate: Plus or minus 10 percent.
   d. Cooling-Water Flow Rate: Plus or minus 10 percent.

Y. Reporting
1. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
2. Status Reports: Prepare weekly **OR** biweekly **OR** monthly, **as directed**, progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

Z. Final Report
1. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
   a. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   b. Include a list of instruments used for procedures, along with proof of calibration.
2. Final Report Contents: In addition to certified field-report data, include the following:
   a. Pump curves.
   b. Fan curves.
   c. Manufacturers' test data.
   d. Field test reports prepared by system and equipment installers.
   e. Other information relative to equipment performance; do not include Shop Drawings and product data.
3. General Report Data: In addition to form titles and entries, include the following data:
   a. Title page.
   b. Name and address of the TAB contractor.

c. Project name.
d. Project location.
e. Architect's name and address.
f. Engineer's name and address.
g. Contractor's name and address.
h. Report date.
i. Signature of TAB supervisor who certifies the report.
j. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
k. Summary of contents including the following:
   1) Indicated versus final performance.
   2) Notable characteristics of systems.
   3) Description of system operation sequence if it varies from the Contract Documents.
l. Nomenclature sheets for each item of equipment.
m. Data for terminal units, including manufacturer's name, type, size, and fittings.
n. Notes to explain why certain final data in the body of reports vary from indicated values.
o. Test conditions for fans and pump performance forms including the following:
   1) Settings for outdoor-, return-, and exhaust-air dampers.
   2) Conditions of filters.
   3) Cooling coil, wet- and dry-bulb conditions.
   4) Face and bypass damper settings at coils.
   5) Fan drive settings including settings and percentage of maximum pitch diameter.
   6) Inlet vane settings for variable-air-volume systems.
   7) Settings for supply-air, static-pressure controller.
   8) Other system operating conditions that affect performance.

4. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
   a. Quantities of outdoor, supply, return, and exhaust airflows.
   b. Water and steam flow rates.
   c. Duct, outlet, and inlet sizes.
   d. Pipe and valve sizes and locations.
   e. Terminal units.
   f. Balancing stations.
   g. Position of balancing devices.
5. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
   a. Unit Data:
      1) Unit identification.
      2) Location.
      3) Make and type.
      4) Model number and unit size.
      5) Manufacturer's serial number.
      6) Unit arrangement and class.
      7) Discharge arrangement.
      8) Sheave make, size in inches (mm), and bore.
      9) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
      10) Number, make, and size of belts.
      11) Number, type, and size of filters.
   b. Motor Data:
      1) Motor make, and frame type and size.
      2) Horsepower and rpm.
      3) Volts, phase, and hertz.
      4) Full-load amperage and service factor.
      5) Sheave make, size in inches (mm), and bore.
      6) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
   c. Test Data (Indicated and Actual Values):
      1) Total air flow rate in cfm (L/s).

2) Total system static pressure in inches wg (Pa).
3) Fan rpm.
4) Discharge static pressure in inches wg (Pa).
5) Filter static-pressure differential in inches wg (Pa).
6) Preheat-coil static-pressure differential in inches wg (Pa).
7) Cooling-coil static-pressure differential in inches wg (Pa).
8) Heating-coil static-pressure differential in inches wg (Pa).
9) Outdoor airflow in cfm (L/s).
10) Return airflow in cfm (L/s).
11) Outdoor-air damper position.
12) Return-air damper position.
13) Vortex damper position.

6. Apparatus-Coil Test Reports:
   a. Coil Data:
      1) System identification.
      2) Location.
      3) Coil type.
      4) Number of rows.
      5) Fin spacing in fins per inch (mm) o.c.
      6) Make and model number.
      7) Face area in sq. ft. (sq. m).
      8) Tube size in NPS (DN).
      9) Tube and fin materials.
      10) Circuiting arrangement.
   b. Test Data (Indicated and Actual Values):
      1) Air flow rate in cfm (L/s).
      2) Average face velocity in fpm (m/s).
      3) Air pressure drop in inches wg (Pa).
      4) Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
      5) Return-air, wet- and dry-bulb temperatures in deg F (deg C).
      6) Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
      7) Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
      8) Water flow rate in gpm (L/s).
      9) Water pressure differential in feet of head or psig (kPa).
      10) Entering-water temperature in deg F (deg C).
      11) Leaving-water temperature in deg F (deg C).
      12) Refrigerant expansion valve and refrigerant types.
      13) Refrigerant suction pressure in psig (kPa).
      14) Refrigerant suction temperature in deg F (deg C).
      15) Inlet steam pressure in psig (kPa).
7. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
   a. Unit Data:
      1) System identification.
      2) Location.
      3) Make and type.
      4) Model number and unit size.
      5) Manufacturer's serial number.
      6) Fuel type in input data.
      7) Output capacity in Btu/h (kW).
      8) Ignition type.
      9) Burner-control types.
      10) Motor horsepower and rpm.
      11) Motor volts, phase, and hertz.
      12) Motor full-load amperage and service factor.

13) Sheave make, size in inches (mm), and bore.
14) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

b. Test Data (Indicated and Actual Values):
1) Total air flow rate in cfm (L/s).
2) Entering-air temperature in deg F (deg C).
3) Leaving-air temperature in deg F (deg C).
4) Air temperature differential in deg F (deg C).
5) Entering-air static pressure in inches wg (Pa).
6) Leaving-air static pressure in inches wg (Pa).
7) Air static-pressure differential in inches wg (Pa).
8) Low-fire fuel input in Btu/h (kW).
9) High-fire fuel input in Btu/h (kW).
10) Manifold pressure in psig (kPa).
11) High-temperature-limit setting in deg F (deg C).
12) Operating set point in Btu/h (kW).
13) Motor voltage at each connection.
14) Motor amperage for each phase.
15) Heating value of fuel in Btu/h (kW).

8. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
a. Unit Data:
1) System identification.
2) Location.
3) Coil identification.
4) Capacity in Btu/h (kW).
5) Number of stages.
6) Connected volts, phase, and hertz.
7) Rated amperage.
8) Air flow rate in cfm (L/s).
9) Face area in sq. ft. (sq. m).
10) Minimum face velocity in fpm (m/s).

b. Test Data (Indicated and Actual Values):
1) Heat output in Btu/h (kW).
2) Air flow rate in cfm (L/s).
3) Air velocity in fpm (m/s).
4) Entering-air temperature in deg F (deg C).
5) Leaving-air temperature in deg F (deg C).
6) Voltage at each connection.
7) Amperage for each phase.

9. Fan Test Reports: For supply, return, and exhaust fans, include the following:
a. Fan Data:
1) System identification.
2) Location.
3) Make and type.
4) Model number and size.
5) Manufacturer's serial number.
6) Arrangement and class.
7) Sheave make, size in inches (mm), and bore.
8) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

b. Motor Data:
1) Motor make, and frame type and size.
2) Horsepower and rpm.
3) Volts, phase, and hertz.
4) Full-load amperage and service factor.
5) Sheave make, size in inches (mm), and bore.
6) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

7) Number, make, and size of belts.

c. Test Data (Indicated and Actual Values):

1) Total airflow rate in cfm (L/s).
2) Total system static pressure in inches wg (Pa).
3) Fan rpm.
4) Discharge static pressure in inches wg (Pa).
5) Suction static pressure in inches wg (Pa).

10. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

a. Report Data:

1) System and air-handling-unit number.
2) Location and zone.
3) Traverse air temperature in deg F (deg C).
4) Duct static pressure in inches wg (Pa).
5) Duct size in inches (mm).
6) Duct area in sq. ft. (sq. m).
7) Indicated air flow rate in cfm (L/s).
8) Indicated velocity in fpm (m/s).
9) Actual air flow rate in cfm (L/s).
10) Actual average velocity in fpm (m/s).
11) Barometric pressure in psig (Pa).

11. Air-Terminal-Device Reports:

a. Unit Data:

1) System and air-handling unit identification.
2) Location and zone.
3) Apparatus used for test.
4) Area served.
5) Make.
6) Number from system diagram.
7) Type and model number.
8) Size.
9) Effective area in sq. ft. (sq. m).

b. Test Data (Indicated and Actual Values):

1) Air flow rate in cfm (L/s).
2) Air velocity in fpm (m/s).
3) Preliminary air flow rate as needed in cfm (L/s).
4) Preliminary velocity as needed in fpm (m/s).
5) Final air flow rate in cfm (L/s).
6) Final velocity in fpm (m/s).
7) Space temperature in deg F (deg C).

12. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

a. Unit Data:

1) System and air-handling-unit identification.
2) Location and zone.
3) Room or riser served.
4) Coil make and size.
5) Flowmeter type.

b. Test Data (Indicated and Actual Values):

1) Air flow rate in cfm (L/s).
2) Entering-water temperature in deg F (deg C).
3) Leaving-water temperature in deg F (deg C).
4) Water pressure drop in feet of head or psig (kPa).
5) Entering-air temperature in deg F (deg C).
6) Leaving-air temperature in deg F (deg C).

13. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
    a. Unit Data:
        1) Unit identification.
        2) Location.
        3) Service.
        4) Make and size.
        5) Model number and serial number.
        6) Water flow rate in gpm (L/s).
        7) Water pressure differential in feet of head or psig (kPa).
        8) Required net positive suction head in feet of head or psig (kPa).
        9) Pump rpm.
        10) Impeller diameter in inches (mm).
        11) Motor make and frame size.
        12) Motor horsepower and rpm.
        13) Voltage at each connection.
        14) Amperage for each phase.
        15) Full-load amperage and service factor.
        16) Seal type.
    b. Test Data (Indicated and Actual Values):
        1) Static head in feet of head or psig (kPa).
        2) Pump shutoff pressure in feet of head or psig (kPa).
        3) Actual impeller size in inches (mm).
        4) Full-open flow rate in gpm (L/s).
        5) Full-open pressure in feet of head or psig (kPa).
        6) Final discharge pressure in feet of head or psig (kPa).
        7) Final suction pressure in feet of head or psig (kPa).
        8) Final total pressure in feet of head or psig (kPa).
        9) Final water flow rate in gpm (L/s).
        10) Voltage at each connection.
        11) Amperage for each phase.
14. Instrument Calibration Reports:
    a. Report Data:
        1) Instrument type and make.
        2) Serial number.
        3) Application.
        4) Dates of use.
        5) Dates of calibration.

AA. Inspections
1. Initial Inspection:
    a. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
    b. Check the following for each system:
        1) Measure airflow of at least 10 percent of air outlets.
        2) Measure water flow of at least 5 percent of terminals.
        3) Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
        4) Verify that balancing devices are marked with final balance position.
        5) Note deviations from the Contract Documents in the final report.
2. Final Inspection:
    a. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by the Owner **OR** Owner **OR** Commissioning Authority, **as directed**.

b. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the Owner **OR** Owner **OR** Commissioning Authority, **as directed**.

c. the Owner **OR** Owner **OR** Commissioning Authority, **as directed**, shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

d. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

e. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

3. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

a. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.

b. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

4. Prepare test and inspection reports.

BB. Additional Tests

1. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

2. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 15043

Task	Specification	Specification Description
15043	15041	Sequence Of Operation
15044	15041	Sequence Of Operation

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SECTION 15048 - AIR DUCT CLEANING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for HVAC air-distribution system cleaning. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

C. Definitions
1. ASCS: Air systems cleaning specialist.
2. NADCA: National Air Duct Cleaners Association.

D. Submittals
1. Qualification Data: For an ASCS.
2. Strategies and procedures plan.
3. Cleanliness verification report.

E. Quality Assurance
1. ASCS Qualifications: A certified member of NADCA.
   a. Certification: Employ an ASCS certified by NADCA on a full-time basis.
   b. Supervisor Qualifications: Certified as an ASCS by NADCA.
2. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.
3. Cleaning Conference: Conduct conference at Project site.

1.2 PRODUCTS (Not Used)

1.3 EXECUTION

A. Examination
1. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.
2. Perform "Project Evaluation and Recommendation" according to NADCA ACR 2006.
3. Prepare written report listing conditions detrimental to performance of the Work.
4. Proceed with work only after unsatisfactory conditions have been corrected.

B. Preparation
1. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:
   a. Supervisor contact information.
   b. Work schedule including location, times, and impact on occupied areas.
   c. Methods and materials planned for each HVAC component type.
   d. Required support from other trades.
   e. Equipment and material storage requirements.
   f. Exhaust equipment setup locations.
2. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.

3. Comply with NADCA ACR 2006, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

C. Cleaning
1. Comply with NADCA ACR 2006.
2. Remove visible surface contaminants and deposits from within the HVAC system.
3. Systems and Components to Be Cleaned:
   a. Air devices for supply and return air.
   b. Air-terminal units.
   c. Ductwork:
      1) Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
      2) Return-air ducts to the air-handling unit.
      3) Exhaust-air ducts.
   d. Air-Handling Units:
      1) Interior surfaces of the unit casing.
      2) Coil surfaces compartment.
      3) Condensate drain pans.
      4) Fans, fan blades, and fan housings.
   e. Filters and filter housings.
4. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.
5. Particulate Collection:
   a. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
   b. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building,
6. Control odors and mist vapors during the cleaning and restoration process.
7. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.
8. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.
9. Clean all air-distribution devices, registers, grilles, and diffusers.
10. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:
    a. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
    b. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
    c. Clean evaporator coils, reheat coils, and other airstream components.
11. Duct Systems:
    a. Create service openings in the HVAC system as necessary to accommodate cleaning.
    b. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
12. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.
13. Mechanical Cleaning Methodology:
    a. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

1) Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
2) Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.

b. Cleaning Mineral-Fiber Insulation Components:
1) Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
2) Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
3) Fibrous materials that become wet shall be discarded and replaced.

14. Coil Cleaning:
a. Measure static-pressure differential across each coil.
b. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
c. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
d. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
e. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
f. Rinse thoroughly with clean water to remove any latent residues.

15. Antimicrobial Agents, Coatings, and Sanitizers:
a. Apply antimicrobial agents, coatings, and sanitizers if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
b. When used, antimicrobial treatments, coatings, and sanitizers shall be applied after the system is rendered clean.
c. Apply antimicrobial agents, coatings, and sanitizers directly onto surfaces of interior ductwork. Fogging is prohibited.
d. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.

D. Cleanliness Verification
1. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.
2. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents, coatings, and sanitizers.
3. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
4. Additional Verification:
a. Perform surface comparison testing or NADCA vacuum test.
b. Conduct NADCA vacuum gravimetric test analysis for nonporous surfaces.
5. Verification of Coil Cleaning:
a. Measure static-pressure differential across each coil.

b. Coil will be considered clean if cleaning restored the coil static-pressure differential within 10 percent of <**Insert inches wg (Pa)**>, the differential measured when the coil was first installed.
OR
Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

6. Prepare a written cleanliness verification report. At a minimum, include the following:
   a. Written documentation of the success of the cleaning.
   b. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
   c. Surface comparison test results if required.
   d. Gravimetric analysis (nonporous surfaces only).
   e. System areas found to be damaged.
7. Photographic Documentation: Comply with requirements listed in Scope of Work.

E. Restoration
1. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.
2. Restore service openings capable of future reopening. Comply with requirements in Division 15 Section "Metal Ducts". Include location of service openings in Project closeout report.
3. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Division 15 Section(s) "Metal Ducts" AND "Nonmetal Ducts"
4. Replace damaged insulation according to Division 15 Section "Hvac Insulation",
5. Ensure that closures do not hinder or alter airflow.
6. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.
7. Reseal fibrous-glass ducts. Comply with requirements in Division 15 Section "Nonmetal Ducts".

END OF SECTION 15048

Task	Specification	Specification Description
15048	01720	Cutting and Patching
15048	02115	Selective Demolition
15048	15041	Sequence Of Operation
15048	15043	Testing, Adjusting, And Balancing

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SECTION 15061 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common work results for fire suppression. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Piping materials and installation instructions common to most piping systems.
b. Mechanical sleeve seals.
c. Sleeves.
d. Escutcheons.
e. Grout.
f. Fire-suppression equipment and piping demolition.
g. Equipment installation requirements common to equipment sections.
h. Painting and finishing.
i. Concrete bases.
j. Supports and anchorages.

C. Definitions
1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
6. The following are industry abbreviations for plastic materials:
a. CPVC: Chlorinated polyvinyl chloride plastic.
7. The following are industry abbreviations for rubber materials:
a. EPDM: Ethylene-propylene-diene terpolymer rubber.
b. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Welding certificates.

E. Quality Assurance
1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

3. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

F. Delivery, Storage, And Handling
1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Pipe, Tube, And Fittings
1. Refer to individual Division 13 for pipe, tube, and fitting materials and joining methods.
2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials
1. Refer to individual Division 13 for special joining materials not listed below.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
      1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
8. Solvent Cements for Joining CPVC Plastic Piping: ASTM F 493.

C. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

D. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.
5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
6. PVC Pipe: ASTM D 1785, Schedule 40.
7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

E. Escutcheons
1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Type: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
5. One-Piece, Stamped-Steel Type: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Type: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Type: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

F. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
   c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Fire-Suppression Demolition
1. Refer to Division 01 Section(s) "Cutting And Patching" AND "Selective Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
   a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

B. Piping Systems - Common Requirements
1. Install piping according to the following requirements and Division 13 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Install piping to allow application of insulation.
11. Select system components with pressure rating equal to or greater than system operating pressure.
12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
    a. New Piping:
        1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
        2) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
        3) Insulated Piping: One-piece, stamped-steel type with spring clips.
        4) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
            a) One-piece, cast-brass type with polished chrome-plated finish.
            OR
            One-piece, stamped-steel type.
        5) Bare Piping at Ceiling Penetrations in Finished Spaces:
            a) One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
            OR
            One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
        6) Bare Piping in Unfinished Service Spaces:
            a) One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
            OR
            One-piece, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw **OR** spring clips, **as directed**.
        7) Bare Piping in Equipment Rooms:
            a) One-piece, cast-brass type.

            One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
        8) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
    b. Existing Piping: Use the following:

    c. Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
    d. Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
    e. Bare Piping at Wall and Floor Penetrations in Finished Spaces:
        1) Split-casting, cast-brass type with chrome-plated finish.
        OR
        Split-plate, stamped-steel type with concealed hinge and spring clips.

f. Bare Piping at Ceiling Penetrations in Finished Spaces:
   1) Split-casting, cast-brass type with chrome-plated finish.
      OR
      Split-plate, stamped-steel type with concealed hinge and set screw.
g. Bare Piping in Unfinished Service Spaces:
   1) Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
      OR
      Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
h. Bare Piping in Equipment Rooms:
   1) Split-casting, cast-brass type.
      OR
      Split-plate, stamped-steel type with set screw or spring clips.
i. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

13. Sleeves are not required for core-drilled holes.
14. Permanent sleeves are not required for holes formed by removable PE sleeves.
15. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
    a. Cut sleeves to length for mounting flush with both surfaces.
       1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
    b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
    c. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
       1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
       2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
       3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
          a) Seal space outside of sleeve fittings with grout.
    d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
17. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
    b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
    c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
18. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

19. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Through-penetration Firestop Systems" for materials.
20. Verify final equipment locations for roughing-in.
21. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

C. Piping Joint Construction
1. Join pipe and fittings according to the following requirements and Division 13 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Para. 1.1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
10. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

D. Painting
1. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Section(s) "Exterior Painting" AND "Interior Painting".
2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

E. Concrete Bases
1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
   c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
   f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

F. Erection Of Metal Supports And Anchorages
1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
3. Field Welding: Comply with AWS D1.1.

G. Erection Of Wood Supports And Anchorages
1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor fire-suppression materials and equipment.
2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
3. Attach to substrates as required to support applied loads.

H. Grouting
1. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout.

END OF SECTION 15061

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SECTION 15061a - COMMON WORK RESULTS FOR PLUMBING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common work results for plumbing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Piping materials and installation instructions common to most piping systems.
b. Transition fittings.
c. Dielectric fittings.
d. Mechanical sleeve seals.
e. Sleeves.
f. Escutcheons.
g. Grout.
h. Plumbing demolition.
i. Equipment installation requirements common to equipment sections.
j. Painting and finishing.
k. Concrete bases.
l. Supports and anchorages.

C. Definitions
1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
6. The following are industry abbreviations for plastic materials:
a. ABS: Acrylonitrile-butadiene-styrene plastic.
b. CPVC: Chlorinated polyvinyl chloride plastic.
c. PE: Polyethylene plastic.
d. PVC: Polyvinyl chloride plastic.
7. The following are industry abbreviations for rubber materials:
a. EPDM: Ethylene-propylene-diene terpolymer rubber.
b. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Welding certificates.

E. Quality Assurance
1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

F. Delivery, Storage, And Handling
1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Pipe, Tube, And Fittings
1. Refer to individual Division 14 for pipe, tube, and fitting materials and joining methods.
2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials
1. Refer to individual Division 14 for special joining materials not listed below.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
      1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
   b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
8. Solvent Cements for Joining Plastic Piping:
   a. ABS Piping: ASTM D 2235.
   b. CPVC Piping: ASTM F 493.
   c. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   d. PVC to ABS Piping Transition: ASTM D 3138.
9. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

C. Transition Fittings
1. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
   a. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.

b. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.
c. Aboveground Pressure Piping: Pipe fitting.

2. Plastic-to-Metal Transition Fittings: CPVC **OR** PVC, **as directed**, one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
3. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
4. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC **OR** PVC, **as directed**, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
5. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

D. Dielectric Fittings

1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
4. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
5. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   a. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
6. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
7. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

E. Mechanical Sleeve Seals

1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

F. Sleeves

1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.
5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
6. PVC Pipe: ASTM D 1785, Schedule 40.

7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

G. Escutcheons
1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Type: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
5. One-Piece, Stamped-Steel Type: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Type: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Type: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

H. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
   c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Plumbing Demolition
1. Refer to Division 01 Section(s) "Cutting And Patching" AND "Selective Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
   a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   c. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   d. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   e. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

B. Piping Systems - Common Requirements
1. Install piping according to the following requirements and Division 14 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Install piping to allow application of insulation.
11. Select system components with pressure rating equal to or greater than system operating pressure.
12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
    a. New Piping:
        1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
        2) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
        3) Insulated Piping: One-piece, stamped-steel type with spring clips.
        4) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
            a) One-piece, cast-brass type with polished chrome-plated finish.
            OR
            One-piece, stamped-steel type.
        5) Bare Piping at Ceiling Penetrations in Finished Spaces:
            a) One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
            OR
            One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
        6) Bare Piping in Unfinished Service Spaces:
            a) One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
            OR
            One-piece, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw **OR** spring clips, **as directed**.
        7) Bare Piping in Equipment Rooms:
            a) One-piece, cast-brass type.
            OR
            One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
        8) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
    b. Existing Piping: Use the following:
        1) Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
        2) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
        3) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
            a) Split-casting, cast-brass type with chrome-plated finish.
            OR
            Split-plate, stamped-steel type with concealed hinge and spring clips.
        4) Bare Piping at Ceiling Penetrations in Finished Spaces:
            a) Split-casting, cast-brass type with chrome-plated finish.
            OR
            Split-plate, stamped-steel type with concealed hinge and set screw.
        5) Bare Piping in Unfinished Service Spaces:
            a) Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
            OR

Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.

6) Bare Piping in Equipment Rooms:
   a) Split-casting, cast-brass type.
      OR
      Split-plate, stamped-steel type with set screw or spring clips.
7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.

13. Sleeves are not required for core-drilled holes.
14. Permanent sleeves are not required for holes formed by removable PE sleeves.
15. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
    a. Cut sleeves to length for mounting flush with both surfaces.
       1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
    b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
    c. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
       1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
       2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
       3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
          a) Seal space outside of sleeve fittings with grout.
    d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
17. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
    b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
    c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
18. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
19. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Through-penetration Firestop Systems" for materials.
20. Verify final equipment locations for roughing-in.
21. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

C. Piping Joint Construction
1. Join pipe and fittings according to the following requirements and Division 14 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Para. 1.1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
   c. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   d. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   e. PVC Nonpressure Piping: Join according to ASTM D 2855.
   f. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
10. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
11. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
12. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   a. Plain-End Pipe and Fittings: Use butt fusion.
   b. Plain-End Pipe and Socket Fittings: Use socket fusion.
13. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

D. Piping Connections
1. Make connections according to the following, unless otherwise indicated:
   a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   c. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

E. Equipment Installation - Common Requirements
1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
3. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.

F. Painting
1. Painting of plumbing systems, equipment, and components is specified in Division 09 Section(s) "Exterior Painting" AND "Interior Painting".
2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

G. Concrete Bases
1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
   c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
   f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

H. Erection Of Metal Supports And Anchorages
1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
3. Field Welding: Comply with AWS D1.1.

I. Erection Of Wood Supports And Anchorages
1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
3. Attach to substrates as required to support applied loads.

J. Grouting
1. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout.

END OF SECTION 15061a

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SECTION 15061b - COMMON WORK RESULTS FOR HVAC

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common work results for HVAC. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Piping materials and installation instructions common to most piping systems.
b. Transition fittings.
c. Dielectric fittings.
d. Mechanical sleeve seals.
e. Sleeves.
f. Escutcheons.
g. Grout.
h. HVAC demolition.
i. Equipment installation requirements common to equipment sections.
j. Painting and finishing.
k. Concrete bases.
l. Supports and anchorages.

C. Definitions
1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
5. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
6. The following are industry abbreviations for plastic materials:
a. CPVC: Chlorinated polyvinyl chloride plastic.
b. PE: Polyethylene plastic.
c. PVC: Polyvinyl chloride plastic.
7. The following are industry abbreviations for rubber materials:
a. EPDM: Ethylene-propylene-diene terpolymer rubber.
b. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Welding certificates.

E. Quality Assurance
1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
2. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

3. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

F. Delivery, Storage, And Handling
1. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
2. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.2 PRODUCTS

A. Pipe, Tube, And Fittings
1. Refer to individual Division 15 for pipe, tube, and fitting materials and joining methods.
2. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

B. Joining Materials
1. Refer to individual Division 15 for special joining materials not listed below.
2. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
a. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
b. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
3. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
4. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
5. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
6. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
7. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
8. Solvent Cements for Joining Plastic Piping:
a. CPVC Piping: ASTM F 493.
b. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
9. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

C. Transition Fittings
1. Plastic-to-Metal Transition Fittings: CPVC **OR** PVC, **as directed**, one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
2. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
3. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC **OR** PVC, **as directed**, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.

D. Dielectric Fittings
1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
4. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
5. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   a. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.
6. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
7. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

E. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

F. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
3. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
4. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.
5. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
6. PVC Pipe: ASTM D 1785, Schedule 40.
7. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

G. Escutcheons
1. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
2. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Type: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
4. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.

5. One-Piece, Stamped-Steel Type: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Type: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Type: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

H. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   a. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
   c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. HVAC Demolition
1. Refer to Division 01 Section(s) "Cutting And Patching" AND "Selective Demolition" for general demolition requirements and procedures.
2. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
   a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
   b. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
   c. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
   d. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
   e. Equipment to Be Removed: Disconnect and cap services and remove equipment.
   f. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
   g. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
3. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

B. Piping Systems - Common Requirements
1. Install piping according to the following requirements and Division 15 specifying piping systems.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
3. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping to permit valve servicing.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.

10. Install piping to allow application of insulation.
11. Select system components with pressure rating equal to or greater than system operating pressure.
12. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
    a. New Piping:
        1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
        2) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
        3) Insulated Piping: One-piece, stamped-steel type with spring clips.
        4) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
            a) One-piece, cast-brass type with polished chrome-plated finish.
            OR
            One-piece, stamped-steel type.
        5) Bare Piping at Ceiling Penetrations in Finished Spaces:
            a) One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
            OR
            One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
        6) Bare Piping in Unfinished Service Spaces:
            a) One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
            OR
            One-piece, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw **OR** spring clips, **as directed**.
        7) Bare Piping in Equipment Rooms:
            a) One-piece, cast-brass type.
            OR
            One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
        8) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
    b. Existing Piping: Use the following:
        1) Chrome-Plated Piping: Split-casting, cast-brass type with chrome-plated finish.
        2) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
        3) Bare Piping at Wall and Floor Penetrations in Finished Spaces:
            a) Split-casting, cast-brass type with chrome-plated finish.
            OR
            Split-plate, stamped-steel type with concealed hinge and spring clips.
        4) Bare Piping at Ceiling Penetrations in Finished Spaces:
            a) Split-casting, cast-brass type with chrome-plated finish.
            OR
            Split-plate, stamped-steel type with concealed hinge and set screw.
        5) Bare Piping in Unfinished Service Spaces:
            a) Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
            OR
            Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
        6) Bare Piping in Equipment Rooms:
            a) Split-casting, cast-brass type.
            OR
            Split-plate, stamped-steel type with set screw or spring clips.
        7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
13. Sleeves are not required for core-drilled holes.
14. Permanent sleeves are not required for holes formed by removable PE sleeves.

15. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
16. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
    a. Cut sleeves to length for mounting flush with both surfaces.
        1) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
    b. Install sleeves in new walls and slabs as new walls and slabs are constructed.
    c. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
        1) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
        2) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
        3) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
            a) Seal space outside of sleeve fittings with grout.
    d. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
17. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
    b. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
    c. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
18. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
    a. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
19. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Through-penetration Firestop Systems" for materials.
20. Verify final equipment locations for roughing-in.
21. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

C. Piping Joint Construction
    1. Join pipe and fittings according to the following requirements and Division 15 specifying piping systems.
    2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
    3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
    4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
    5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Para. 1.1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   c. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
   d. PVC Nonpressure Piping: Join according to ASTM D 2855.
10. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
11. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
12. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   a. Plain-End Pipe and Fittings: Use butt fusion.
   b. Plain-End Pipe and Socket Fittings: Use socket fusion.
13. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

D. Piping Connections
1. Make connections according to the following, unless otherwise indicated:
   a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
   b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
   c. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
   d. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

E. Equipment Installation - Common Requirements
1. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
2. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
3. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
4. Install equipment to allow right of way for piping installed at required slope.

F. Painting
1. Painting of HVAC systems, equipment, and components is specified in Division 09 Section(s) "Exterior Painting" AND "Interior Painting".
2. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

G. Concrete Bases
1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
   c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
   f. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   g. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

H. Erection Of Metal Supports And Anchorages
1. Refer to Division 05 Section "Metal Fabrications" for structural steel.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
3. Field Welding: Comply with AWS D1.1.

I. Erection Of Wood Supports And Anchorages
1. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
2. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
3. Attach to substrates as required to support applied loads.

J. Grouting
1. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
2. Clean surfaces that will come into contact with grout.
3. Provide forms as required for placement of grout.
4. Avoid air entrapment during placement of grout.
5. Place grout, completely filling equipment bases.
6. Place grout on concrete bases and provide smooth bearing surface for equipment.
7. Place grout around anchors.
8. Cure placed grout.

END OF SECTION 15061b

SECTION 15061c - DOMESTIC WATER PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for domestic water piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
b. Encasement for piping.
c. Specialty valves.
d. Flexible connectors.
e. Water meters furnished by utility company for installation by Contractor.
OR
Water meters.
f. Escutcheons.
g. Sleeves and sleeve seals.
h. Wall penetration systems.

C. Performance Requirements
1. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

D. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Field quality-control reports.

E. Quality Assurance
1. Piping materials shall bear label, stamp, or other markings of specified testing agency.
2. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping, **as directed**.
3. Comply with NSF 61 for potable domestic water piping and components.

F. Project Conditions
1. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
a. Notify the Owner no fewer than two days in advance of proposed interruption of water service.
b. Do not proceed with interruption of water service without the Owner's written permission.

1.2 PRODUCTS

A. Piping Materials

1. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

B. Copper Tube And Fittings
1. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.
   a. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
   b. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   c. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
   d. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
   e. Copper Pressure-Seal-Joint Fittings:
      1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
      2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.
   f. Copper Push-on-Joint Fittings:
      1) Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.
   g. Copper-Tube Extruded-Tee Connections:
      1) Description: Tee formed in copper tube according to ASTM F 2014.
   h. Grooved-Joint Copper-Tube Appurtenances:
      1) Copper Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
      2) Grooved-End-Tube Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.
2. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) and ASTM B 88, Type L (ASTM B 88M, Type B) water tube, annealed temper.
   a. Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
   b. Copper Pressure-Seal-Joint Fittings:
      1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
      2) NPS 3 and NPS 4 (DN 80 and DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

C. Ductile-Iron Pipe And Fittings
1. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   a. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
   b. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.
      1) Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
2. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
   a. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.
      1) Gaskets: AWWA C111, rubber.
   b. Compact-Pattern, Push-on-Joint Fittings: AWWA C153, ductile iron.
      1) Gaskets: AWWA C111, rubber.
3. Plain-End, Ductile-Iron Pipe: AWWA C151.
   a. Grooved-Joint, Ductile-Iron-Pipe Appurtenances:
      1) Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.

2) Grooved-End, Ductile-Iron-Pipe Couplings: AWWA C606 for ductile-iron-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

D. Galvanized-Steel Pipe And Fittings
1. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B, Standard Weight. Include ends matching joining method.
a. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Standard Weight, seamless steel pipe with threaded ends.
b. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
c. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
d. Flanges: ASME B16.1, Class 125, cast iron.
e. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:
1) Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 47/A 47M, malleable-iron casting; ASTM A 106/A 106M, steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
2) Grooved-End-Pipe Couplings for Galvanized-Steel Piping: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

E. CPVC Piping
1. CPVC Pipe: ASTM F 441/F 441M, Schedule 40 and Schedule 80.
a. CPVC Socket Fittings: ASTM F 438 for Schedule 40 and ASTM F 439 for Schedule 80.
b. CPVC Threaded Fittings: ASTM F 437, Schedule 80.
2. CPVC Piping System: ASTM D 2846/D 2846M, SDR 11, pipe and socket fittings.
3. CPVC Tubing System: ASTM D 2846/D 2846M, SDR 11, tube and socket fittings.

F. PEX Tube And Fittings
1. PEX Distribution System: ASTM F 877, SDR 9 tubing.
a. Fittings for PEX Tube: ASTM F 1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.
b. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 877; with plastic or corrosion-resistant-metal valve for each outlet.

G. PVC Pipe And Fittings
1. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
a. PVC Socket Fittings: ASTM D 2466 for Schedule 40 and ASTM D 2467 for Schedule 80.
b. PVC Schedule 80 Threaded Fittings: ASTM D 2464.

H. Piping Joining Materials
1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
3. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
4. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
5. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
a. Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

I. Encasement For Piping
1. Standard: ASTM A 674 or AWWA C105.
2. Form: Sheet **OR** Tube, **as directed**.
3. Material: LLDPE film of 0.008-inch (0.20-mm) **OR** LLDPE film of 0.008-inch (0.20-mm) minimum thickness or high-density, cross-laminated PE film of 0.004-inch (0.10-mm) **OR** High-density, cross-laminated PE film of 0.004-inch (0.10-mm), **as directed**, minimum thickness.
4. Color: Black **OR** Natural, **as directed**.

J. Specialty Valves
1. Comply with requirements in Division 15 Section "General-duty Valves For Plumbing Piping" for general-duty metal valves.
2. Comply with requirements in Division 15 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.
3. CPVC Union Ball Valves:
   a. Description:
      1) Standard: MSS SP-122.
      2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      3) Body Material: CPVC.
      4) Body Design: Union type.
      5) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
      6) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
      7) Ball: CPVC; full port.
      8) Seals: PTFE or EPDM-rubber O-rings.
      9) Handle: Tee shaped.
4. PVC Union Ball Valves:
   a. Description:
      1) Standard: MSS SP-122.
      2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      3) Body Material: PVC.
      4) Body Design: Union type.
      5) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
      6) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
      7) Ball: PVC; full port.
      8) Seals: PTFE or EPDM-rubber O-rings.
      9) Handle: Tee shaped.
5. CPVC Non-Union Ball Valves:
   a. Description:
      1) Standard: MSS SP-122.
      2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      3) Body Material: CPVC.
      4) Body Design: Non-union type.

5) End Connections: Socket or threaded.
6) Ball: CPVC; full or reduced port.
7) Seals: PTFE or EPDM-rubber O-rings.
8) Handle: Tee shaped.

6. PVC Non-Union Ball Valves:
   a. Description:
      1) Standard: MSS SP-122.
      2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      3) Body Material: PVC.
      4) Body Design: Non-union type.
      5) End Connections: Socket or threaded.
      6) Ball: PVC; full or reduced port.
      7) Seals: PTFE or EPDM-rubber O-rings.
      8) Handle: Tee shaped.
7. CPVC Butterfly Valves:
   a. Description:
      1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      2) Body Material: CPVC.
      3) Body Design: Lug or wafer type.
      4) Seat: EPDM rubber.
      5) Seals: PTFE or EPDM-rubber O-rings.
      6) Disc: CPVC.
      7) Stem: Stainless steel.
      8) Handle: Lever.
8. PVC Butterfly Valves:
   a. Description:
      1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      2) Body Material: PVC.
      3) Body Design: Lug or wafer type.
      4) Seat: EPDM rubber.
      5) Seals: PTFE or EPDM-rubber O-rings.
      6) Disc: PVC.
      7) Stem: Stainless steel.
      8) Handle: Lever.
9. CPVC Ball Check Valves:
   a. Description:
      1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      2) Body Material: CPVC.
      3) Body Design: Union-type ball check.
      4) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
      5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
      6) Ball: CPVC.
      7) Seals: EPDM- or FKM-rubber O-rings.
10. PVC Ball Check Valves:
   a. Description:
      1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
      2) Body Material: PVC.
      3) Body Design: Union-type ball check.

4) End Connections for Valves NPS 2 (DN 50) and Smaller: Detachable, socket **OR** threaded, **as directed**.
5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Detachable, socket **OR** threaded **OR** flanged, **as directed**.
6) Ball: PVC.
7) Seals: EPDM- or FKM-rubber O-rings.

11. CPVC Gate Valves:
    a. Description:
    1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
    2) Body Material: CPVC.
    3) Body Design: Nonrising stem.
    4) End Connections for Valves NPS 2 (DN 50) and Smaller: Socket **OR** Threaded, **as directed**.
    5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket **OR** Threaded **OR** Flanged, **as directed**.
    6) Gate and Stem: Plastic.
    7) Seals: EPDM rubber.
    8) Handle: Wheel.
12. PVC Gate Valves:
    a. Description:
    1) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, at 73 deg F (23 deg C).
    2) Body Material: PVC.
    3) Body Design: Nonrising stem.
    4) End Connections for Valves NPS 2 (DN 50) and Smaller: Socket **OR** Threaded, **as directed**.
    5) End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket **OR** Threaded **OR** Flanged, **as directed**.
    6) Gate and Stem: Plastic.
    7) Seals: EPDM rubber.
    8) Handle: Wheel.

K. Transition Fittings
1. General Requirements:
    a. Same size as pipes to be joined.
    b. Pressure rating at least equal to pipes to be joined.
    c. End connections compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Sleeve-Type Transition Coupling: AWWA C219.
4. Plastic-to-Metal Transition Fittings:
    a. Description: CPVC **OR** PVC, **as directed**, one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket threaded, **as directed**, end.
5. Plastic-to-Metal Transition Unions:
    a. Description: CPVC **OR** PVC, **as directed**, four-part union. Include brass or stainless-steel, **as directed**, threaded end, solvent-cement-joint or threaded, **as directed**, plastic end, rubber O-ring, and union nut.

L. Dielectric Fittings
1. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
2. Dielectric Unions:

a. Description:
1) Pressure Rating: 150 psig (1035 kPa) **OR** 250 psig (1725 kPa), **as directed**, at 180 deg F (82 deg C).
2) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:
a. Description:
1) Factory-fabricated, bolted, companion-flange assembly.
2) Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa) minimum **OR** 300 psig (2070 kPa), **as directed**.
3) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Kits:
a. Description:
1) Nonconducting materials for field assembly of companion flanges.
2) Pressure Rating: 150 psig (1035 kPa).
3) Gasket: Neoprene or phenolic.
4) Bolt Sleeves: Phenolic or polyethylene.
5) Washers: Phenolic with steel backing washers.

5. Dielectric Couplings:
a. Description:
1) Galvanized-steel coupling.
2) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
3) End Connections: Female threaded.
4) Lining: Inert and noncorrosive, thermoplastic.

6. Dielectric Nipples:
a. Description:
1) Electroplated steel nipple complying with ASTM F 1545.
2) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
3) End Connections: Male threaded or grooved.
4) Lining: Inert and noncorrosive, propylene.

M. Flexible Connectors
1. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
a. Working-Pressure Rating: Minimum 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**.
b. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
c. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.

2. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
a. Working-Pressure Rating: Minimum 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**.
b. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
c. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

N. Water Meters
1. Displacement-Type Water Meters:
a. Description:
1) Standard: AWWA C700.
2) Pressure Rating: 150-psig (1035-kPa) working pressure.
3) Body Design: Nutating disc; totalization meter.
4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility.
5) Case: Bronze.
6) End Connections: Threaded.

2. Turbine-Type Water Meters:

a. Description:
   1) Standard: AWWA C701.
   2) Pressure Rating: 150-psig (1035-kPa) working pressure.
   3) Body Design: Turbine; totalization meter.
   4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
   5) Case: Bronze.
   6) End Connections for Meters NPS 2 (DN 50) and Smaller: Threaded.
   7) End Connections for Meters NPS 2-1/2 (DN 65) and Larger: Flanged.

3. Compound-Type Water Meters:
   a. Description:
      1) Standard: AWWA C702.
      2) Pressure Rating: 150-psig (1035-kPa) working pressure.
      3) Body Design: With integral mainline and bypass meters; totalization meter.
      4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
      5) Case: Bronze.
      6) Pipe Connections: Flanged.
4. Fire-Service-Type Water Meters:
   a. Description:
      1) Standard: AWWA C703 and UL listing.
      2) Pressure Rating: 175-psig (1200-kPa) working pressure.
      3) Body Design:
         a) Proportional, Detector-Type Water Meters: With meter on bypass.
            i. Bypass Meter: AWWA C701, turbine **OR** AWWA C702, compound, **as directed**, type with bronze case; size not less than one-half nominal size of main-line meter.
         b) Turbine-Type Water Meters: With strainer, and with meter on bypass.
            i. Strainer: Full size, matching water meter.
            ii. Bypass Meter: AWWA C701, turbine type with bronze case; not less than NPS 2 (DN 50).
      4) Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
      5) Case: Bronze.
      6) Pipe Connections for Meters NPS 2 (DN 50) and Smaller: Threaded.
      7) Pipe Connections for Meters NPS 2-1/2 (DN 65) and Larger: Flanged.
5. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.
   OR
   Remote Registration System: Encoder type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

O. Escutcheons
   1. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
   2. One Piece, Cast Brass: Polished, chrome-plated **OR** rough-brass, **as directed**, finish with setscrews.
   3. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.
   4. One Piece, Stamped Steel: Chrome-plated finish with setscrew **OR** spring clips, **as directed**.
   5. Split Casting, Cast Brass: Polished, chrome-plated **OR** rough-brass, **as directed**, finish with concealed hinge and setscrew.
   6. Split Plate, Stamped Steel: Chrome-plated finish with concealed **OR** exposed-rivet, **as directed**, hinge, setscrew **OR** spring clips, **as directed**.
   7. One-Piece Floor Plates: Cast-iron flange with holes for fasteners, **as directed**.

8. Split-Casting Floor Plates: Cast brass with concealed hinge.

P. Sleeves
1. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
4. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
5. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
6. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.
7. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with setscrews.

Q. Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM-rubber **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
   c. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

R. Wall Penetration Systems
1. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.
   a. Carrier-Pipe Deflection: Up to 5 percent without leakage.
   b. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
   c. Housing-to-Sleeve Gasket: EPDM rubber **OR** NBR, **as directed**.
   d. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber **OR** NBR, **as directed**.
   e. Pipe Sleeve: AWWA C151, ductile-iron pipe **OR** ASTM A 53/A 53M, Schedule 40, zinc-coated steel pipe, **as directed**.

S. Grout
1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink; recommended for interior and exterior applications.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Earthwork
1. Comply with requirements in Division 02 Section "Earthwork" for excavating, trenching, and backfilling.

B. Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

3. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
4. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.
5. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 15 Section "Meters And Gages For Plumbing Piping" for pressure gages and Division 15 Section "Domestic Water Piping Specialties" for drain valves and strainers.
6. Install shutoff valve immediately upstream of each dielectric fitting.
7. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 15 Section "Domestic Water Piping Specialties" for pressure-reducing valves.
8. Install domestic water piping level with 0.25 percent slope downward toward drain **OR** without pitch, **as directed**, and plumb.
9. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
10. Install seismic restraints on piping. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
11. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
12. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
13. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
14. Install piping adjacent to equipment and specialties to allow service and maintenance.
15. Install piping to permit valve servicing.
16. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
17. Install piping free of sags and bends.
18. Install fittings for changes in direction and branch connections.
19. Install PEX piping with loop at each change of direction of more than 90 degrees.
20. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
21. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 15 Section "Meters And Gages For Plumbing Piping" for pressure gages.
22. Install thermostats in hot-water circulation piping. Comply with requirements in Division 15 Section "Domestic Water Pumps" for thermostats.
23. Install thermometers on inlet **OR** inlet and outlet, **as directed**, piping from each water heater. Comply with requirements in Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.

C. Joint Construction
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
4. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

5. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
6. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
7. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.
8. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
9. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.
10. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.
11. Steel-Piping Grooved Joints: Cut **OR** Roll, **as directed**, groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
12. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
13. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements. Apply primer.
    b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
    c. PVC Piping: Join according to ASTM D 2855.
14. PEX Piping Joints: Join according to ASTM F 1807.
15. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

D. Valve Installation
1. General-Duty Valves: Comply with requirements in Division 15 Section "General-duty Valves For Plumbing Piping" for valve installations.
2. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.
3. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 15 Section "Domestic Water Piping Specialties".
    a. Hose-End Drain Valves: At low points in water mains, risers, and branches.
    b. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.
4. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 (DN 50) and smaller and butterfly valves for piping NPS 2-1/2 (DN 65) and larger. Comply with requirements in Division 15 Section "Domestic Water Piping Specialties" for balancing valves.
5. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 15 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

E. Transition Fitting Installation
1. Install transition couplings at joints of dissimilar piping.
2. Transition Fittings in Underground Domestic Water Piping:

a. NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
b. NPS 2 (DN 50) and Larger: Sleeve-type coupling.

3. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings **OR** unions, **as directed**.

F. Dielectric Fitting Installation
1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings **OR** nipples **OR** unions, **as directed**.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges **OR** flange kits **OR** nipples, **as directed**.
4. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

G. Flexible Connector Installation
1. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump, **as directed**.
2. Install bronze-hose flexible connectors in copper domestic water tubing.
3. Install stainless-steel-hose flexible connectors in steel domestic water piping.

H. Water Meter Installation
1. Rough-in domestic water piping for water meter installation, and install water meters, **as directed**, according to utility company's requirements.
2. Water meters will be furnished and installed by utility company.
OR
Install water meters according to AWWA M6 and utility company's requirements.
3. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
OR
Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
OR
Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
OR
Install fire-service water meters with shutoff valves on water-meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.
4. Install remote registration system according to standards of utility company and of authorities having jurisdiction.

I. Hanger And Support Installation
1. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
2. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support products and installation.
a. Vertical Piping: MSS Type 8 or 42, clamps.
b. Individual, Straight, Horizontal Piping Runs:
1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
3) Longer Than 100 Feet (30 m) If Indicated: MSS Type 49, spring cushion rolls.
c. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
d. Base of Vertical Piping: MSS Type 52, spring hangers.
3. Support vertical piping and tubing at base and at each floor.

4. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
5. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   b. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   c. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   d. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
   e. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
   f. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
   g. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
6. Install supports for vertical copper tubing every 10 feet (3 m).
7. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   b. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   c. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   d. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   e. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   f. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
   g. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
   h. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
8. Install supports for vertical steel piping every 15 feet (4.5 m).
9. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.
   b. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
   c. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
   d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
   e. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
   f. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
10. Install supports for vertical CPVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller, and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.
11. Install vinyl-coated hangers for PEX piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1 (DN 25) and Smaller: 32 inches (815 mm) with 3/8-inch (10-mm) rod.
12. Install hangers for vertical PEX piping every 48 inches (1200 mm).
13. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
    b. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
    c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
    d. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
    e. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
14. Install supports for vertical PVC piping every 48 inches (1200 mm).
15. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

J. Connections
   1. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Install piping adjacent to equipment and machines to allow service and maintenance.

3. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
4. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
   a. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   b. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
   c. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 15 Section(s) "Plumbing Fixtures" OR "Medical Plumbing Fixtures" OR "Emergency Plumbing Fixtures" OR "Security Plumbing Fixtures", **as directed**, for connection sizes.
   d. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

K. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors.
2. Escutcheons for New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
   c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.
   d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
   e. Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
   f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
3. Escutcheons for Existing Piping:
   a. Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
   b. Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
   d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
   e. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
   f. Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
   g. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

L. Sleeve Installation

1. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
2. Sleeves are not required for core-drilled holes.
3. Permanent sleeves are not required for holes formed by removable PE sleeves.
4. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
5. Install sleeves in new partitions, slabs, and walls as they are built.
6. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
7. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
8. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals **OR** wall penetration systems, **as directed**, specified in this Section.
9. Seal space outside of sleeves in concrete slabs and walls with grout.
10. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
11. Install sleeve materials according to the following applications:
    a. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE **OR** Molded PVC **OR** Steel pipe, **as directed**.
    b. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe **OR** Stack sleeve fittings, **as directed**.
        1) Extend sleeves 2 inches (50 mm) above finished floor level.
        2) For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
    c. Sleeves for Piping Passing through Gypsum-Board Partitions:
        1) PVC pipe **OR** Steel pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
        2) Galvanized-steel sheet sleeves for pipes NPS 6 (DN 150) and larger.
        3) Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
    d. Sleeves for Piping Passing through Concrete Roof Slabs: Molded PE **OR** Molded PVC **OR** Steel pipe, **as directed**.
    e. Sleeves for Piping Passing through Exterior Concrete Walls:
        1) Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
        2) Cast-iron wall pipe sleeves for pipes NPS 6 (DN 150) and larger.
        3) Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
        4) Do not use sleeves when wall penetration systems are used.
    f. Sleeves for Piping Passing through Interior Concrete Walls:
        1) PVC pipe **OR** Steel pipe, **as directed**, sleeves for pipes smaller than NPS 6 (DN 150).
        2) Galvanized-steel sheet sleeves for pipes NPS 6 (DN 150) and larger.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems" for firestop materials and installations.

M. Sleeve Seal Installation
1. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
2. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe

and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

N. Wall Penetration System Installation
1. Install wall penetration systems in new, exterior concrete walls.
2. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

O. Identification
1. Identify system components. Comply with requirements in Division 15 Section "Identification For Plumbing Piping And Equipment" for identification materials and installation.
2. Label pressure piping with system operating pressure.

P. Field Quality Control
1. Perform tests and inspections.
2. Piping Inspections:
   a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
   b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
      1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
      2) Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
   c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
   d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
3. Piping Tests:
   a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
   b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
   c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   e. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
   f. Prepare reports for tests and for corrective action required.
4. Domestic water piping will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

Q. Adjusting
1. Perform the following adjustments before operation:
   a. Close drain valves, hydrants, and hose bibbs.
   b. Open shutoff valves to fully open position.
   c. Open throttling valves to proper setting.
   d. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

1) Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
2) Adjust calibrated balancing valves to flows indicated.

e. Remove plugs used during testing of piping and for temporary sealing of piping during installation.

f. Remove and clean strainer screens. Close drain valves and replace drain plugs.

g. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.

h. Check plumbing specialties and verify proper settings, adjustments, and operation.

R. Cleaning

1. Clean and disinfect potable and non-potable, **as directed**, domestic water piping as follows:
   a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   b. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
      1) Flush piping system with clean, potable water until dirty water does not appear at outlets.
      2) Fill and isolate system according to either of the following:
         a) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
         b) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
      3) Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      4) Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
2. Clean non-potable domestic water piping as follows:
   a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
   b. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
      1) Flush piping system with clean, potable water until dirty water does not appear at outlets.
      2) Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
3. Prepare and submit reports of purging and disinfecting activities.
4. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

S. Piping Schedule

1. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
2. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
3. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
4. Under-building-slab, domestic water, building service piping, NPS 3 (DN 80) and smaller, shall be one of the following:
   a. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper solder-joint fittings; and brazed **OR** copper pressure-seal fittings; and pressure-sealed, **as directed**, joints.
   b. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
5. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 (DN 100 to DN 200) and larger, shall be one of the following:

a. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; wrought-copper solder-joint fittings; and brazed joints.
b. Mechanical-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, mechanical-joint fittings; and mechanical joints.
c. Push-on-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, push-on-joint fittings; and gasketed joints.
d. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
e. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.

6. Under-building slab, combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12 (DN 150 to DN 300), shall be one of the following:
   a. Mechanical-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, mechanical-joint fittings; and mechanical joints.
   b. Push-on-joint, ductile-iron pipe; standard-pattern **OR** compact-pattern, **as directed**, push-on-joint fittings; and gasketed joints.
   c. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
7. Under-building-slab, domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
   a. Hard **OR** Soft, **as directed**, copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper solder-joint fittings; and brazed **OR** copper pressure-seal-joint fittings; and pressure-sealed, **as directed**, joints.
   b. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
8. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
   a. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
   b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; cast-copper **OR** wrought-copper, **as directed**, solder-joint fittings; and brazed **OR** soldered, **as directed**, joints.
   c. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B, **as directed**; copper pressure-seal-joint fittings; and pressure-sealed joints.
   d. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B) **OR**, **as directed**; copper push-on-joint fittings; and push-on joints.
   e. CPVC, Schedule 40 pipe; CPVC, Schedule 40 **OR** Schedule 80 pipe; CPVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
   f. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
   g. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints. NPS 1-1/2 (DN 40) and NPS 2 (DN 50) CPVC pipe with CPVC socket fittings may be used instead of tubing.
   h. PEX Tube, NPS 1 (DN 25) and smaller; fittings for PEX tube; and crimped joints.
   i. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
9. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
   a. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; cast-copper **OR** wrought-copper, **as directed**, solder-joint fittings; and brazed **OR** soldered, **as directed**, joints.
   b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; copper pressure-seal-joint fittings; and pressure-sealed joints.
   c. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B, **as directed**; grooved-joint copper-tube appurtenances; and grooved joints.

d. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
e. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
f. CPVC, Schedule 40 pipe; CPVC, Schedule 40 **OR** Schedule 80 pipe; CPVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
g. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
h. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.

10. Aboveground domestic water piping, NPS 5 to NPS 8 (DN 125 to DN 200), shall be one of the following:
    a. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; cast-copper **OR** wrought-copper, **as directed**, solder-joint fittings; and brazed **OR** soldered, **as directed**, joints.
    b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**; grooved-joint copper-tube appurtenances; and grooved joints.
    c. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
    d. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
    e. CPVC, Schedule 40 pipe; CPVC, Schedule 40 **OR** Schedule 80 pipe; CPVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
    f. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
    g. PVC, Schedule 40 pipe; PVC, Schedule 40 **OR** Schedule 80 pipe; PVC, Schedule 80, **as directed**, socket fittings; and solvent-cemented joints.
11. Aboveground, combined domestic-water-service and fire-service-main piping, NPS 6 to NPS 12 (DN 150 to DN300), shall be one of the following:
    a. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
    b. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
    c. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.

T. Valve Schedule
1. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
    a. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
    b. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
    c. Hot-Water Circulation Piping, Balancing Duty: Calibrated **OR** Memory-stop, **as directed**, balancing valves.
    d. Drain Duty: Hose-end drain valves.
2. Use check valves to maintain correct direction of domestic water flow to and from equipment.
3. Iron grooved-end valves may be used with grooved-end piping.
4. CPVC and PVC valves matching piping materials may be used.

END OF SECTION 15061c

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SECTION 15061d - SANITARY WASTE AND VENT PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for sanitary waste and vent piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following for soil, waste, and vent piping inside the building:
   a. Pipe, tube, and fittings.
   b. Special pipe fittings.
   c. Encasement for underground metal piping.

C. Definitions
1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. LLDPE: Linear, low-density polyethylene plastic.
4. NBR: Acrylonitrile-butadiene rubber.
5. PE: Polyethylene plastic.
6. PVC: Polyvinyl chloride plastic.
7. TPE: Thermoplastic elastomer.

D. Performance Requirements
1. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
   a. Soil, Waste, and Vent Piping: 10-foot head of water (30 kPa).
   b. Sanitary Sewer, Force-Main Piping: 50 psig (345 kPa) **OR** 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
2. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

E. Submittals
1. Product Data: For pipe, tube, fittings, and couplings.
2. LEED Submittal:
   a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings:
   a. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
   b. Sovent Drainage System: Include plans, elevations, sections, and details.
4. Field quality-control inspection and test reports.

F. Quality Assurance
1. Piping materials shall bear label, stamp, or other markings of specified testing agency.
2. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

1.2 PRODUCTS

A. Piping Materials
1. Refer to Part 1.3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy class(es).
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

C. Hubless Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
3. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
   b. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
   c. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
4. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Steel Pipe And Fittings
1. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.
2. Drainage Fittings: ASME B16.12, galvanized, **as directed**, threaded, cast-iron drainage pattern.
3. Pressure Fittings:
   a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
   b. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
   c. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, **as directed**, standard pattern.
   d. Cast-Iron Flanges: ASME B16.1, Class 125.
   e. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized, **as directed**.
4. Grooved-Joint Systems:
   a. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, galvanized, **as directed**, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, galvanized, **as directed**, ductile-iron casting; with dimensions matching steel pipe.
   b. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

E. Stainless-Steel Pipe And Fittings
1. Pipe and Fittings: ASME A112.3.1, drainage pattern with socket and spigot ends.
2. Gaskets: Lip seals shaped to fit socket groove, with plastic backup ring.
   a. Material: EPDM, unless NBR is indicated.

F. Ductile-Iron Pipe And Fittings
1. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

a. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
b. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
   a. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   b. Gaskets: AWWA C111, rubber.
3. Grooved-Joint Systems:
   a. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
   b. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
4. Flanges: ASME 16.1, Class 125, cast iron.

G. Copper Tube And Fittings
1. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
   a. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
2. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.
   a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
   b. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   c. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
3. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
   a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

H. ABS Pipe And Fittings
1. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.
2. Cellular-Core ABS Pipe: ASTM F 628, Schedule 40.
3. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
4. Solvent Cement and Adhesive Primer:
   a. Use ABS solvent cement that has a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

I. PVC Pipe And Fittings
1. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
   a. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
2. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
   a. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
3. Cellular-Core, Sewer and Drain Series, PVC Pipe: ASTM F 891, Series PS 100.
   a. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Series PS 100 sewer and drain pipe.
4. Solvent Cement and Adhesive Primer:
   a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

J. Special Pipe Fittings
1. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
   a. Sleeve Materials:
      1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
      2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
2. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
3. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
4. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   a. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
   b. Gasket Material: Natural or synthetic rubber.
   c. Metal Component Finish: Corrosion-resistant coating or material.
5. Flexible Ball Joints: Ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include gasketed ball-joint section and ductile-iron gland, rubber gasket, and steel bolts.
6. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
7. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

K. Encasement For Underground Metal Piping
1. Description: ASTM A 674 or AWWA C105, high-density, crosslaminated PE film of 0.004-inch (0.10-mm) **OR** LLDPE film of 0.008-inch (0.20-mm), **as directed**, minimum thickness.
2. Form: Sheet **OR** Tube, **as directed**.
3. Color: Black **OR** Natural, **as directed**.

1.3 EXECUTION

A. Excavation
1. Refer to Division 02 Section "Earthwork" for excavating, trenching, and backfilling.

B. Piping Applications
1. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
2. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller shall be any of the following:
   a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   b. Hubless cast-iron soil pipe and fittings and sovent stack fittings, **as directed**; standard, shielded, stainless-steel **OR** heavy-duty shielded, stainless-steel **OR** rigid, unshielded, **as directed**, couplings; and hubless-coupling joints.
   c. Steel pipe, drainage fittings, and threaded joints.

d. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
e. Copper DWV tube, copper drainage fittings, and soldered joints.
f. Solid-wall **OR** Cellular-core, **as directed**, ABS pipe, ABS socket fittings, and solvent-cemented joints.
g. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
h. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **OR** Rigid, unshielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3. Aboveground, soil and waste piping NPS 5 (DN 125) and larger shall be any of the following:
   a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   b. Hubless cast-iron soil pipe and fittings and sovent stack fittings, **as directed**; standard, **OR** heavy-duty, **as directed**, shielded, stainless-steel couplings; and hubless-coupling joints.
   c. Steel pipe, drainage fittings, and threaded joints.
   d. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
   e. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
4. Aboveground, vent piping NPS 4 (DN 100) and smaller shall be any of the following:
   a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   b. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel **OR** heavy-duty shielded, stainless-steel **OR** rigid, unshielded, **as directed**, couplings; and hubless-coupling joints.
   c. Steel pipe, drainage fittings, and threaded joints.
   d. Stainless-steel pipe and fittings gaskets, and gasketed joints.
   e. Copper DWV tube, copper drainage fittings, and soldered joints.
      1) Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2 (DN 65 and DN 90): Hard copper tube, Type M (Type C); copper pressure fittings; and soldered joints.
   f. Solid-wall **OR** Cellular-core, **as directed**, ABS pipe, ABS socket fittings, and solvent-cemented joints.
   g. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
   h. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **OR** Rigid, unshielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
5. Aboveground, vent piping NPS 5 (DN 125) and larger shall be any of the following:
   a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   b. Hubless cast-iron soil pipe and fittings; standard, **OR** heavy-duty, **as directed**, shielded, stainless-steel couplings; and hubless-coupling joints.
   c. Steel pipe, drainage fittings, and threaded joints.
   d. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
   e. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
6. Underground, soil, waste, and vent piping NPS 4 (DN 100) and smaller shall be any of the following:
   a. Extra-Heavy **OR** Service, **as directed**, class, cast-iron soil piping; gaskets; and gasketed **OR** calking materials; and calked, **as directed**, joints.
   b. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel **OR** heavy-duty shielded, stainless-steel **OR** heavy-duty shielded, cast-iron **OR** rigid, unshielded, **as directed**, couplings; and hubless-coupling joints.
   c. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
   d. Cellular-core **OR** Solid wall, **as directed**, ABS pipe, ABS socket fittings, and solvent-cemented joints.

e. Cellular-core **OR** Solid wall, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
f. Cellular-core, Sewer and Drain Series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
g. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **OR** Rigid, unshielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

7. Underground, soil and waste piping NPS 5 (DN 125) and larger shall be any of the following:
   a. Extra-Heavy **OR** Service, **as directed**, class, cast-iron soil piping; gaskets; and gasketed **OR** calking materials; and calked, **as directed**, joints.
   b. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel **OR** heavy-duty shielded, stainless-steel **OR** heavy-duty shielded, cast-iron, **as directed**, couplings; and hubless-coupling joints.
   c. Cellular-core **OR** Solid-wall, **as directed**, Schedule 40, PVC pipe; PVC socket fittings; and solvent-cemented joints.
   d. Cellular-core, Sewer and Drain Series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
   e. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
8. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 (DN 40 and DN 50) shall be any of the following:
   a. Hard copper tube, Type L (Type B) **OR** Type M (Type C), **as directed**; copper pressure fittings; and soldered joints.
   b. Steel pipe, pressure fittings, and threaded joints.
9. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 (DN 65 to DN 150) shall be any of the following:
   a. Hard copper tube, Type L (Type B) **OR** Type M (Type C), **as directed**; copper pressure fittings; and soldered joints.
   b. Steel pipe, pressure fittings, and threaded joints.
   c. Grooved-end steel pipe, grooved-joint system fittings and couplings, and grooved joints.
10. Underground sanitary-sewage force mains NPS 4 (DN 100) and smaller shall be any of the following:
   a. Hard **OR** Soft, **as directed**, copper tube, Type L (Type B); copper **OR** wrought-copper, **as directed**, pressure fittings; and soldered joints.
   b. Steel pipe, pressure fittings, and threaded joints.
      1) Include grooved-joint system fittings and couplings and grooved joints where indicated.
   c. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron fittings; glands, gaskets, and bolts; and mechanical joints.
      1) Include grooved-joint system fittings and couplings and grooved joints where indicated.
   d. Push-on-joint, ductile-iron pipe; push-on-joint ductile-iron fittings; gaskets; and gasketed joints.
      1) Include grooved-joint system fittings and couplings and grooved joints where indicated.
   e. Pressure pipe couplings, if dissimilar pipe materials or piping with small difference in OD must be joined.
11. Underground sanitary-sewage force mains NPS 5 (DN 125) and larger shall be any of the following:
   a. Steel pipe, pressure fittings, and threaded joints.
   b. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron fittings; glands, gaskets, and bolts; and mechanical-joint joints.
   c. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron fittings; gaskets; and gasketed joints.

d. Pressure pipe couplings, if dissimilar pipe materials or piping with small difference in OD must be joined.

C. Piping Installation

1. Sanitary sewer piping outside the building is specified in Division 02 Section "Sanitary Sewerage"
2. Basic piping installation requirements are specified in Division 15 Section "Common Work Results For Plumbing".
3. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
4. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
5. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.
6. Install underground, steel, force-main piping. Install encasement on piping according to ASTM A 674 or AWWA C105, **as directed**.
7. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside the building between wall and floor penetrations and connection to sanitary sewer piping outside the building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
   a. Install encasement on piping according to ASTM A 674 or AWWA C105.
8. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
   a. Install encasement on piping according to ASTM A 674 or AWWA C105.
9. Install underground, ductile-iron, special pipe fittings according to AWWA C600.
   a. Install encasement on piping according to ASTM A 674 or AWWA C105.
10. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Common Work Results For Plumbing".

    OR

    Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.
11. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
    a. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
12. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
13. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
14. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
    a. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
    b. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
    c. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
15. Install engineered soil and waste drainage and vent piping systems as follows:
    a. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
    b. Sovent Drainage System: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.

c. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

16. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
17. Install ABS soil and waste drainage and vent piping according to ASTM D 2661.
18. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
19. Install underground ABS and PVC soil and waste drainage piping according to ASTM D 2321.
20. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

D. Joint Construction

1. Basic piping joint construction requirements are specified in Division 15 Section "Common Work Results For Plumbing".
2. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
3. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
4. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
5. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
6. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
7. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

E. Valve Installation

1. General valve installation requirements are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
2. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
   a. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
   b. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
3. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
4. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
   a. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   b. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
   c. Install backwater valves in accessible locations.
   d. Backwater valve are specified in Division 15 Section "Sanitary Waste Piping Specialties".

F. Hanger And Support Installation

1. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
2. Pipe hangers and supports are specified in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment". Install the following:
   a. Vertical Piping: MSS Type 8 or Type 42, clamps.
   b. Install individual, straight, horizontal piping runs according to the following:
      1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      3) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
   c. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   d. Base of Vertical Piping: MSS Type 52, spring hangers.
3. Install supports according to Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment".
4. Support vertical piping and tubing at base and at each floor.

5. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
6. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
   c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
   d. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
   e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
7. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
8. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   b. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   c. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   d. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   e. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   f. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
   g. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
   h. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
9. Install supports for vertical steel piping every 15 feet (4.5 m).
10. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 2 (DN 50): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
    b. NPS 3 (DN 80): 96 inches (2400 mm) with 1/2-inch (13-mm) rod.
    c. NPS 4 (DN 100): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
    d. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
11. Install supports for vertical stainless-steel piping every 10 feet (3 m).
12. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
    b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
    c. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
    d. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
    e. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
    f. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
13. Install supports for vertical copper tubing every 10 feet (3 m).
14. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
    b. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
    c. NPS 4 and 5 (DN 100 and 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
    d. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
    e. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
15. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).
16. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

G. Connections
   1. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
   3. Connect drainage and vent piping to the following:

a. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
b. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
c. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
d. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

4. Connect force-main piping to the following:
   a. Sanitary Sewer: To exterior force main or sanitary manhole.
   b. Sewage Pumps: To sewage pump discharge.

H. Field Quality Control

1. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
2. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
3. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
4. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   a. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   b. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   c. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   d. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
   e. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   f. Prepare reports for tests and required corrective action.
5. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   a. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   b. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

c. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
d. Prepare reports for tests and required corrective action.

I. Cleaning
1. Clean interior of piping. Remove dirt and debris as work progresses.
2. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
3. Place plugs in ends of uncompleted piping at end of day and when work stops.

J. Protection
1. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 15061d

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SECTION 15061e - STORM DRAINAGE PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for storm drainage piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following storm drainage piping inside the building:
   a. Pipe, tube, and fittings.
   b. Special pipe fittings.
   c. Encasement for underground metal piping.

C. Definitions
1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. LLDPE: Linear, low-density polyethylene plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.
5. TPE: Thermoplastic elastomer.

D. Performance Requirements
1. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
   a. Storm Drainage Piping: 10-foot head of water (30 kPa).
   b. Storm Drainage, Force-Main Piping: 50 psig (345 kPa) **OR** 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
2. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

E. Submittals
1. Product Data: For pipe, tube, fittings, and couplings.
2. LEED Submittal:
   a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings:
   a. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.
   b. Controlled-Flow Storm Drainage System: Include calculations, plans, and details.
4. Field quality-control inspection and test reports.

F. Quality Assurance
1. Piping materials shall bear label, stamp, or other markings of specified testing agency.
2. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

1.2 PRODUCTS

A. Piping Materials

1. Refer to Part 1.3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy class(es).
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

C. Hubless Cast-Iron Soil Pipe And Fittings
1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
   a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
   b. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.
   c. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.
3. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Steel Pipe And Fittings
1. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.
2. Drainage Fittings: ASME B16.12, galvanized, **as directed**, threaded, cast-iron drainage pattern.
3. Pressure Fittings:
   a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
   b. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
   c. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, **as directed**, standard pattern.
   d. Cast-Iron Flanges: ASME B16.1, Class 125.
   e. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized, **as directed**.
4. Grooved-Joint Systems:
   a. Grooved-End, Steel-Piping Fittings: ASTM A 47/A 47M, galvanized, **as directed**, malleable-iron casting; ASTM A 106, galvanized-steel pipe; or ASTM A 536, galvanized, **as directed**, ductile-iron casting; with dimensions matching steel pipe.
   b. Grooved-End, Steel-Piping Couplings: AWWA C606, for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

E. Ductile-Iron Pipe And Fittings
1. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
   a. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   b. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
2. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
   a. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   b. Gaskets: AWWA C111, rubber.
3. Grooved-Joint Systems:

a. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
b. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

4. Flanges: ASME 16.1, Class 125, cast iron.

F. Copper Tube And Fittings
1. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
a. Copper Drainage Fittings: ASME B16.23, cast-copper or ASME B16.29, wrought-copper, solder-joint fittings.
2. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.
a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
b. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
c. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
3. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

G. ABS Pipe And Fittings
1. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.
2. Cellular-Core ABS Pipe: ASTM F 628, Schedule 40.
3. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
4. Solvent Cement and Adhesive Primer:
a. Use ABS solvent cement that has a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. PVC Pipe And Fittings
1. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
2. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
a. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
3. Cellular-Core, Sewer and Drain Series, PVC Pipe: ASTM F 891, Series PS 100.
a. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Series PS 100 sewer and drain pipe.
4. Solvent Cement and Adhesive Primer:
a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

I. Special Pipe Fittings
1. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
a. Sleeve Materials:
1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
3) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

2. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
3. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
4. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
   a. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
   b. Gasket Material: Natural or synthetic rubber.
   c. Metal Component Finish: Corrosion-resistant coating or material.
5. Flexible Ball Joints: Ductile-iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include gasketed ball-joint section and ductile-iron gland, rubber gasket, and steel bolts.
6. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
7. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

J. Encasement For Underground Metal Piping
1. Description: ASTM A 674 or AWWA C105, high-density, crosslaminated PE film of 0.004-inch (0.10-mm) **OR** LLDPE film of 0.008-inch (0.20-mm), **as directed**, minimum thickness.
2. Form: Sheet **OR** Tube, **as directed**.
3. Color: Black **OR** Natural, **as directed**.

1.3 EXECUTION

A. Excavation
1. Refer to Division 02 Section "Earthwork" for excavating, trenching, and backfilling.

B. Piping Applications
1. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
2. Aboveground storm drainage piping NPS 6 (DN 150) and smaller shall be any of the following:
   a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   b. Hubless cast-iron soil pipe and fittings; standard, **OR** heavy-duty, **as directed**, shielded, stainless-steel couplings; and coupled joints.
   c. Steel pipe, drainage fittings, and threaded joints.
   d. Copper DWV tube, copper drainage fittings, and soldered joints.
   e. Solid-wall **OR** Cellular-core, **as directed**, ABS pipe, ABS socket fittings, and solvent-cemented joints.
   f. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
   g. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **OR** Rigid, unshielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
3. Aboveground, storm drainage piping NPS 8 (DN 200) and larger shall be any of the following:
   a. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
   b. Hubless cast-iron soil pipe and fittings; standard, **OR** heavy-duty, **as directed**, shielded, stainless-steel couplings; and coupled joints.
   c. Steel pipe, drainage fittings, and threaded joints.

d. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
e. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

4. Underground storm drainage piping NPS 6 (DN 150) and smaller shall be any of the following:
   a. Extra-heavy **OR** Service, **as directed**, class, cast-iron soil pipe and fittings; gaskets; and gasketed **OR** calking materials; and calked, **as directed**, joints.
   b. Hubless cast-iron soil pipe and fittings; standard, **OR** heavy-duty, **as directed**, shielded, stainless-steel couplings; and coupled joints.
   c. Steel pipe, drainage fittings, and threaded joints.
   d. Solid-wall **OR** Cellular-core, **as directed**, ABS pipe, ABS socket fittings, and solvent-cemented joints.
   e. Solid-wall **OR** Cellular-core, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
   f. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **OR** Rigid, unshielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
5. Underground, storm drainage piping NPS 8 (DN 200) and larger shall be any of the following:
   a. Extra-Heavy **OR** Service, **as directed**, class, cast-iron soil pipe and fittings; gaskets; and gasketed **OR** calking materials; and calked, **as directed**, joints.
   b. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel **OR** heavy-duty shielded, stainless-steel **OR** heavy-duty shielded, cast-iron, **as directed**, couplings; and coupled joints.
   c. Cellular-core **OR** Solid-wall, **as directed**, PVC pipe, PVC socket fittings, and solvent-cemented joints.
   d. Cellular-core, Sewer and Drain Series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
   e. Dissimilar Pipe-Material Couplings: Flexible, **OR** Shielded, **as directed**, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
6. Aboveground storm drainage force mains NPS 1-1/2 and NPS 2 (DN 40 and DN 50) shall be any of the following:
   a. Hard copper tube, Type L (Type B) **OR** Type M (Type C), **as directed**,; copper pressure fittings; and soldered joints.
   b. Steel pipe, pressure fittings, and threaded joints.
7. Aboveground storm drainage force mains NPS 2-1/2 and NPS 6 (DN 65 and DN 150) shall be any of the following:
   a. Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
   b. Steel pipe, pressure fittings, and threaded joints.
   c. Grooved-end steel pipe, grooved-joint system fittings and couplings, and grooved joints.
8. Underground storm drainage force mains NPS 4 (DN 100) and smaller shall be any of the following:
   a. Hard **OR** Soft, **as directed**, copper tube, Type L (Type B); copper **OR** wrought-copper, **as directed**, pressure fittings; and soldered joints.
   b. Steel pipe, pressure fittings, and threaded joints.
      1) Include grooved-joint system fittings and couplings and grooved joints where indicated.
   c. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron fittings; glands, gaskets, and bolts; and mechanical joints.
      1) Include grooved-joint system fittings and couplings and grooved joints where indicated.
   d. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron fittings; gaskets; and gasketed joints.
      1) Include grooved-joint system fittings and couplings and grooved joints where indicated.
   e. Pressure pipe couplings if dissimilar pipe materials or piping with small difference in OD must be joined.

9. Underground storm drainage force mains NPS 5 (DN 125) and larger shall be any of the following:
   a. Steel pipe, pressure fittings, and threaded joints.
   b. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile-iron fittings; glands, gaskets, and bolts; and mechanical-joint joints.
   c. Push-on-joint, ductile-iron pipe; push-on-joint, ductile-iron fittings; gaskets; and gasketed joints.
   d. Pressure pipe couplings if dissimilar pipe materials or piping with small difference in OD must be joined.

C. Piping Installation
1. Storm sewer and drainage piping outside the building are specified in Division 02 Section "Storm Drainage".
2. Basic piping installation requirements are specified in Division 15 Section "Common Work Results For Plumbing".
3. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
4. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 15 Section "Storm Drainage Piping Specialties".
5. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
6. Install underground, steel, force-main piping. Install encasement on piping according to ASTM A 674 or AWWA C105, **as directed**.
7. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to storm sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
   a. Install encasement on piping according to ASTM A 674 or AWWA C105.
8. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
   a. Install encasement on piping according to ASTM A 674 or AWWA C105.
9. Install underground, ductile-iron, special pipe fittings according to AWWA C600.
   a. Install encasement on piping according to ASTM A 674 or AWWA C105.
10. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Common Work Results For Plumbing".
    OR
    Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.
11. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
    a. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
12. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
13. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
14. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
    a. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
    b. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.
15. Install force mains at elevations indicated.

16. Install engineered controlled-flow storm drainage piping in locations indicated.
17. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
18. Install ABS storm drainage piping according to ASTM D 2661.
19. Install PVC storm drainage piping according to ASTM D 2665.
20. Install underground ABS and PVC storm drainage piping according to ASTM D 2321.
21. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

D. Joint Construction
1. Basic piping joint construction requirements are specified in Division 15 Section "Common Work Results For Plumbing".
2. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
3. Hub-and-Spigot, Cast-Iron Soil Piping Calked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
4. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
5. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
6. Grooved Joints: Cut groove ends of pipe and assemble grooved ends of pipes, grooved-end fittings, and grooved-end-piping couplings according to AWWA C606.
7. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

E. Valve Installation
1. General valve installation requirements are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
2. Shutoff Valves: Install shutoff valve on each sump pump discharge.
   a. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
   b. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
3. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.
4. Backwater Valves: Install backwater valves in piping subject to backflow.
   a. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
   b. Install backwater valves in accessible locations.
   c. Backwater valve are specified in Division 15 Section "Storm Drainage Piping Specialties".

F. Hanger And Support Installation
1. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
2. Pipe hangers and supports are specified in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment". Install the following:
   a. Vertical Piping: MSS Type 8 or Type 42, clamps.
   b. Individual, Straight, Horizontal Piping Runs: According to the following:
      1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      3) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
   c. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   d. Base of Vertical Piping: MSS Type 52, spring hangers.
3. Install supports according to Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment".
4. Support vertical piping and tubing at base and at each floor.
5. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

6. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
   c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
   d. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
   e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
   f. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
7. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
8. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   b. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   c. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   d. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   e. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   f. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
   g. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
   h. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
9. Install supports for vertical steel piping every 15 feet (4.5 m).
10. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
    b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
    c. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
    d. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
    e. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
    f. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
11. Install supports for vertical copper tubing every 10 feet (3 m).
12. Install hangers for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
    b. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
    c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
    d. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
    e. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
13. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).
14. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

G. Connections
   1. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
   3. Connect storm drainage piping to roof drains and storm drainage specialties.
   4. Connect force-main piping to the following:
      a. Storm Sewer: To exterior force main or storm manhole.
      b. Sump Pumps: To sump pump discharge.

H. Field Quality Control

1. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
   b. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
2. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
3. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
4. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   a. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
   b. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   c. Test Procedure: Test storm drainage piping, except outside leaders, **as directed**, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   d. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   e. Prepare reports for tests and required corrective action.
5. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
   a. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
   b. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
   c. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
   d. Prepare reports for tests and required corrective action.

I. Cleaning
1. Clean interior of piping. Remove dirt and debris as work progresses.
2. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
3. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 15061e

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SECTION 15061f - HYDRONIC PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hydronic piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   a. Hot-water heating piping.
   b. Chilled-water piping.
   c. Dual-temperature heating and cooling water piping.
   d. Condenser-water piping.
   e. Glycol cooling-water piping.
   f. Makeup-water piping.
   g. Condensate-drain piping.
   h. Blowdown-drain piping.
   i. Air-vent piping.
   j. Safety-valve-inlet and -outlet piping.

C. Definitions
1. PTFE: Polytetrafluoroethylene.
2. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
3. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

D. Performance Requirements
1. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
   a. Hot-Water Heating Piping: **psig (kPa),** as directed by the Owner at 200 deg F (93 deg C).
   b. Chilled-Water Piping: **psig (kPa),** as directed by the Owner at 200 deg F (93 deg C).
   c. Dual-Temperature Heating and Cooling Water Piping: **psig (kPa),** ethylene at 200 deg F (93 deg C).
   d. Condenser-Water Piping: **psig (kPa),** as directed by the Owner at 150 deg F (66 deg C).
   e. Glycol Cooling-Water Piping: **psig (kPa),** as directed by the Owner at 150 deg F (66 deg C).
   f. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
   g. Condensate-Drain Piping: 150 deg F (66 deg C).
   h. Blowdown-Drain Piping: 200 deg F (93 deg C).
   i. Air-Vent Piping: 200 deg F (93 deg C).
   j. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

E. Submittals
1. Product Data: For each type of the following:
   a. Plastic pipe and fittings with solvent cement.
   b. RTRP and RTRF with adhesive.
   c. Pressure-seal fittings.
   d. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   e. Air control devices.

f. Chemical treatment.
g. Hydronic specialties.

2. LEED Submittal:
   a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: Detail, at 1/4 (1:50) scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
4. Welding certificates.
5. Qualification Data: For Installer.
6. Field quality-control test reports.
7. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.
8. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

F. Quality Assurance
1. Installer Qualifications:
   a. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
   b. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
2. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
4. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.2 PRODUCTS

A. Copper Tube And Fittings
1. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed**.
2. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
3. DWV Copper Tubing: ASTM B 306, Type DWV.
4. Wrought-Copper Fittings: ASME B16.22.
   a. Grooved-End Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze casting.
   b. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated, **as directed**, EPDM gasket rated for minimum 230 deg F (110 deg C) for use with housing, and steel bolts and nuts.
5. Copper or Bronze Pressure-Seal Fittings:
   a. Housing: Copper.
   b. O-Rings and Pipe Stops: EPDM.

c. Tools: Manufacturer's special tools.
d. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).

6. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
7. Wrought-Copper Unions: ASME B16.22.

B. Steel Pipe And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 1.3 "Piping Applications" Article.
2. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 1.3 "Piping Applications" Article.
3. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 1.3 "Piping Applications" Article.
4. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 1.3 "Piping Applications" Article.
5. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 1.3 "Piping Applications" Article.
6. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
7. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   a. Material Group: 1.1.
   b. End Connections: Butt welding.
   c. Facings: Raised face.
8. Grooved Mechanical-Joint Fittings and Couplings:
   a. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
   b. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
9. Steel Pressure-Seal Fittings:
   a. Housing: Steel.
   b. O-Rings and Pipe Stop: EPDM.
   c. Tools: Manufacturer's special tool.
   d. Minimum 300-psig (2070-kPa) working-pressure rating at 230 deg F (110 deg C).
10. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

C. Plastic Pipe And Fittings

1. CPVC Plastic Pipe: ASTM F 441/F 441M, Schedules 40 and 80, plain ends as indicated in Part 1.3 "Piping Applications" Article.
2. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.
3. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 1.3 "Piping Applications" Article.
4. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.

D. Fiberglass Pipe And Fittings

1. RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.
2. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.
3. Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum 1/8-inch (3.2-mm) thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.

E. Joining Materials
1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
      1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
3. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
5. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
6. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
7. Solvent Cements for Joining Plastic Piping:
   a. CPVC Piping: ASTM F 493.
      1) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
      2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
      1) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
      2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.
   a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

F. Transition Fittings
1. Plastic-to-Metal Transition Fittings:
   a. CPVC **OR** PVC, **as directed**, one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.
2. Plastic-to-Metal Transition Unions:
   a. MSS SP-107, CPVC **OR** PVC, **as directed**, union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

G. Dielectric Fittings
1. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions:
   a. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
4. Dielectric Flanges:
   a. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
5. Dielectric-Flange Kits:
   a. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

b. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

6. Dielectric Couplings:
   a. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
7. Dielectric Nipples:
   a. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

H. Valves
1. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 15 Section(s) "General-duty Valves For Plumbing Piping" OR "General-duty Valves For Hvac Piping".
2. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 15 Section "Hvac Instrumentation And Controls".
3. Plastic Ball Valves:
   a. Body: One-, two-, or three-piece CPVC or PVC to match piping.
   b. Ball: Full-port CPVC or PVC to match piping.
   c. Seats: PTFE.
   d. Seals: EPDM.
   e. End Connections: Socket, union, or flanged.
   f. Handle Style: Tee shape.
   g. CWP Rating: Equal to piping service.
   h. Maximum Operating Temperature: Equal to piping service.
   i. Comply with MSS SP-122.
4. Plastic Butterfly Valves:
   a. Body: PVC or CPVC to match piping wafer type for installation between flanges.
   b. Disc: EPDM-coated steel.
   c. Seats: PTFE.
   d. Handle Style: Locking lever.
   e. CWP Rating: Equal to piping service.
   f. Maximum Operating Temperature: Equal to piping service.
5. Plastic Check Valves:
   a. Body: One-, two-, or three-piece PVC or CPVC to match piping.
   b. Ends: Socket or flanged.
   c. Seats: PTFE.
   d. Check Style: Swing or ball type.
   e. CWP Rating: Equal to piping service.
   f. Maximum Operating Temperature: Equal to piping service.
6. Bronze, Calibrated-Orifice, Balancing Valves:
   a. Body: Bronze, ball or plug type with calibrated orifice or venturi.
   b. Ball: Brass or stainless steel.
   c. Plug: Resin.
   d. Seat: PTFE.
   e. End Connections: Threaded or socket.
   f. Pressure Gage Connections: Integral seals for portable differential pressure meter.
   g. Handle Style: Lever, with memory stop to retain set position.
   h. CWP Rating: Minimum 125 psig (860 kPa).
   i. Maximum Operating Temperature: 250 deg F (121 deg C).
7. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
   a. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
   b. Ball: Brass or stainless steel.
   c. Stem Seals: EPDM O-rings.
   d. Disc: Glass and carbon-filled PTFE.
   e. Seat: PTFE.

f. End Connections: Flanged or grooved.
g. Pressure Gage Connections: Integral seals for portable differential pressure meter.
h. Handle Style: Lever, with memory stop to retain set position.
i. CWP Rating: Minimum 125 psig (860 kPa).
j. Maximum Operating Temperature: 250 deg F (121 deg C).

8. Diaphragm-Operated, Pressure-Reducing Valves:
   a. Body: Bronze or brass.
   b. Disc: Glass and carbon-filled PTFE.
   c. Seat: Brass.
   d. Stem Seals: EPDM O-rings.
   e. Diaphragm: EPT.
   f. Low inlet-pressure check valve.
   g. Inlet Strainer: removable without system shutdown.
   h. Valve Seat and Stem: Noncorrosive.
   i. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
9. Diaphragm-Operated Safety Valves:
   a. Body: Bronze or brass.
   b. Disc: Glass and carbon-filled PTFE.
   c. Seat: Brass.
   d. Stem Seals: EPDM O-rings.
   e. Diaphragm: EPT.
   f. Wetted, Internal Work Parts: Brass and rubber.
   g. Inlet Strainer: removable without system shutdown.
   h. Valve Seat and Stem: Noncorrosive.
   i. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
10. Automatic Flow-Control Valves:
   a. Body: Brass or ferrous metal.
   b. Piston and Spring Assembly: Stainless steel **OR** Corrosion resistant, **as directed**, tamper proof, self cleaning, and removable.
   c. Combination Assemblies: Include bonze or brass-alloy ball valve.
   d. Identification Tag: Marked with zone identification, valve number, and flow rate.
   e. Size: Same as pipe in which installed.
   f. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
   g. Minimum CWP Rating: 175 psig (1207 kPa) **OR** 300 psig (2070 kPa), **as directed**.
   h. Maximum Operating Temperature: 200 deg F (93 deg C) **OR** 250 deg F (121 deg C), **as directed**.

I. Air Control Devices
1. Manual Air Vents:
   a. Body: Bronze.
   b. Internal Parts: Nonferrous.
   c. Operator: Screwdriver or thumbscrew.
   d. Inlet Connection: NPS 1/2 (DN 15).
   e. Discharge Connection: NPS 1/8 (DN 6).
   f. CWP Rating: 150 psig (1035 kPa).
   g. Maximum Operating Temperature: 225 deg F (107 deg C).
2. Automatic Air Vents:
   a. Body: Bronze or cast iron.
   b. Internal Parts: Nonferrous.
   c. Operator: Noncorrosive metal float.
   d. Inlet Connection: NPS 1/2 (DN 15).

e. Discharge Connection: NPS 1/4 (DN 8).
f. CWP Rating: 150 psig (1035 kPa).
g. Maximum Operating Temperature: 240 deg F (116 deg C).

3. Expansion Tanks:
   a. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   b. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.
   c. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
   d. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- (20-mm-) diameter gage glass, and slotted-metal glass guard.
4. Diaphragm-Type **OR** Bladder-Type, **as directed**, Expansion Tanks:
   a. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   b. Diaphragm **OR** Bladder, **as directed**: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
   c. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
5. Tangential-Type Air Separators:
   a. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
   b. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
   c. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
   d. Blowdown Connection: Threaded.
   e. Size: Match system flow capacity.
6. In-Line Air Separators:
   a. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
   b. Maximum Working Pressure: Up to 175 psig (1207 kPa).
   c. Maximum Operating Temperature: Up to 300 deg F (149 deg C).
7. Air Purgers:
   a. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
   b. Maximum Working Pressure: 150 psig (1035 kPa).
   c. Maximum Operating Temperature: 250 deg F (121 deg C).

J. Chemical Treatment
1. Bypass Chemical Feeder: Welded steel construction; 125-psig (860-kPa) working pressure; 5-gal. (19-L) capacity; with fill funnel and inlet, outlet, and drain valves.
   a. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.
2. Ethylene and Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions.

K. Hydronic Piping Specialties
1. Y-Pattern Strainers:

a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
c. Strainer Screen: 40 **OR** 60, **as directed**,-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
d. CWP Rating: 125 psig (860 kPa).

2. Basket Strainers:
   a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
   b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
   c. Strainer Screen: 40 **OR** 60, **as directed**,-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   d. CWP Rating: 125 psig (860 kPa).
3. T-Pattern Strainers:
   a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
   b. End Connections: Grooved ends.
   c. Strainer Screen: 40 **OR** 60, **as directed**,-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
   d. CWP Rating: 750 psig (5170 kPa).
4. Stainless-Steel Bellow, Flexible Connectors:
   a. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
   b. End Connections: Threaded or flanged to match equipment connected.
   c. Performance: Capable of 3/4-inch (20-mm) misalignment.
   d. CWP Rating: 150 psig (1035 kPa).
   e. Maximum Operating Temperature: 250 deg F (121 deg C).
5. Spherical, Rubber, Flexible Connectors:
   a. Body: Fiber-reinforced rubber body.
   b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
   c. Performance: Capable of misalignment.
   d. CWP Rating: 150 psig (1035 kPa).
   e. Maximum Operating Temperature: 250 deg F (121 deg C).
6. Expansion fittings are specified in Division 15 Section(s) "Expansion Fittings And Loops For Plumbing Piping" OR "Expansion Fittings And Loops For Hvac Piping".

1.3 EXECUTION

1. Hot-water heating piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
   a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
   b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
   c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
   d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
2. Hot-water heating piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
   a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
   b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
   c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.

d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
e. RTRP and RTRF with adhesive or flanged joints.

3. Hot-water heating piping installed belowground and within slabs shall be either of the following:
   a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
   b. RTRP and RTRF with adhesive or flanged joints.
4. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
   a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
   b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
   c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
   d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
5. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
   a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
   b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
   c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
   d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
   e. RTRP and RTRF with adhesive or flanged joints.
6. Chilled-water piping installed belowground and within slabs shall be either of the following:
   a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
   b. RTRP and RTRF with adhesive or flanged joints.
7. Dual-temperature heating and cooling water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
   a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
   b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
   c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
   d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
8. Dual-temperature heating and cooling water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
   a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
   b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
   c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
   d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
   e. RTRP and RTRF with adhesive or flanged joints.
9. Dual-temperature heating and cooling water piping installed belowground and within slabs shall be either of the following:
   a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
   b. RTRP and RTRF with adhesive or flanged joints.
10. Condenser-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
    a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.

b. Schedule 80 **OR** 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.

11. Condenser-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
    a. Type L (B) **OR** M (C), **as directed**,, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
    b. Schedule 80 **OR** 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
    c. Schedule 80 **OR** 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
    d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
    e. RTRP and RTRF with adhesive or flanged joints.
12. Condenser-water piping installed belowground and within slabs shall be either of the following:
    a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
    b. RTRP and RTRF with adhesive or flanged joints.
13. Glycol cooling-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
    a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed **OR** pressure-seal, **as directed**, joints.
    b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; Class 125, cast-iron **OR** 150, malleable-iron **OR** 250, cast-iron **OR** 300, malleable-iron, **as directed**, fittings; cast-iron flanges and flange fittings; and threaded joints.
    c. Schedule 5 steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
    d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
14. Glycol cooling-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:
    a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
    b. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
    c. Schedule 40 **OR** 30 **OR** 20, **as directed**, steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
    d. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings and solvent-welded joints.
    e. RTRP and RTRF with adhesive or flanged joints.
15. Glycol cooling-water piping installed belowground and within slabs shall be either of the following:
    a. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints. Use the fewest possible joints.
    b. RTRP and RTRF with adhesive or flanged joints.
16. Makeup-water piping installed aboveground shall be either of the following:
    a. Type L (B) **OR** M (C), **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
    b. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings, and solvent-welded joints.
17. Makeup-Water Piping Installed Belowground and within Slabs: Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
18. Condensate-Drain Piping: Type M (C) **OR** DWV, **as directed**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints, **as directed**.
    OR
    Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

19. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
20. Air-Vent Piping:
    a. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
    b. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.
21. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

B. Valve Applications
1. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
2. Install throttling-duty **OR** calibrated-orifice, balancing, **as directed**, valves at each branch connection to return main.
3. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
4. Install check valves at each pump discharge and elsewhere as required to control flow direction.
5. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
6. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

C. Piping Installations
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
5. Install piping to permit valve servicing.
6. Install piping at indicated slopes.
7. Install piping free of sags and bends.
8. Install fittings for changes in direction and branch connections.
9. Install piping to allow application of insulation.
10. Select system components with pressure rating equal to or greater than system operating pressure.
11. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
12. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
13. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
14. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
15. Install branch connections to mains using mechanically formed, **as directed**, tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
16. Install valves according to Division 15 Section(s) "General-duty Valves For Plumbing Piping" OR "General-duty Valves For Hvac Piping".
17. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

18. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
19. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).
20. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 15 Section(s) "Expansion Fittings And Loops For Plumbing Piping" OR "Expansion Fittings And Loops For Hvac Piping".
21. Identify piping as specified in Division 15 Section(s) "Identification For Plumbing Piping And Equipment" OR "Identification For Hvac Piping And Equipment".

D. Hangers And Supports
1. Hanger, support, and anchor devices are specified in Division 15 Section(s) "Hangers And Supports For Plumbing Piping And Equipment" OR "Hangers And Supports For Hvac Piping And Equipment". Comply with the following requirements for maximum spacing of supports.
2. Seismic restraints are specified in Division 15 Section(s) "Vibration And Seismic Controls For Fire-suppression Piping And Equipment" OR "Vibration And Seismic Controls For Plumbing Piping And Equipment" OR "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install the following pipe attachments:
   a. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
   b. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
   c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
   d. Spring hangers to support vertical runs.
   e. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
   f. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
4. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   a. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
   b. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
   c. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
   d. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
   e. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
   f. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 1/2 inch (12 mm).
   g. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (12 mm).
   h. NPS 3-1/2 (DN 90): Maximum span, 13 feet (4 m); minimum rod size, 1/2 inch (12 mm).
   i. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 5/8 inch (16 mm).
   j. NPS 5 (DN 125): Maximum span, 16 feet (4.9 m); minimum rod size, 5/8 inch (16 mm).
   k. NPS 6 (DN 150): Maximum span, 17 feet (5.2 m); minimum rod size, 3/4 inch (20 mm).
   l. NPS 8 (DN 200): Maximum span, 19 feet (5.8 m); minimum rod size, 3/4 inch (20 mm).
   m. NPS 10 (DN 250): Maximum span, 22 feet (6.7 m); minimum rod size, 7/8 inch (20 mm).
   n. NPS 12 (DN 300): Maximum span, 23 feet (7 m); minimum rod size, 7/8 inch (20 mm).
   o. NPS 14 (DN 350): Maximum span, 25 feet (7.6 m); minimum rod size, 1 inch (24 mm).
   p. NPS 16 (DN 400): Maximum span, 27 feet (8.2 m); minimum rod size, 1 inch (24 mm).
   q. NPS 18 (DN 450): Maximum span, 28 feet (8.5 m); minimum rod size, 1 inch (24 mm).
   r. NPS 20 (DN 500): Maximum span, 30 feet (9.1 m); minimum rod size, 1-1/4 inches (30 mm).
5. Install hangers for drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
   a. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 3/8 inch (10 mm).
   b. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 3/8 inch (10 mm).
   c. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).

d. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
e. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
f. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 1/2 inch (12 mm).
g. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (12 mm).

6. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
7. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
8. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

E. Pipe Joint Construction
1. Join pipe and fittings according to the following requirements and Division 15 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1.1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
   c. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
   d. PVC Nonpressure Piping: Join according to ASTM D 2855.
10. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
11. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.
12. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
13. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

F. Hydronic Specialties Installation
1. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
   OR

Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

2. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
3. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.

   OR

   Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
4. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches (1200 mm) above the floor. Install feeder in minimum NPS 3/4 (DN 20) bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 (DN 20) pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.
5. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
   a. Install tank fittings that are shipped loose.
   b. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

   OR

   Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

G. Terminal Equipment Connections
1. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
2. Install control valves in accessible locations close to connected equipment.
3. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
4. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 15 Section(s) "Meters And Gages For Plumbing Piping" OR "Meters And Gages For Hvac Piping".

H. Chemical Treatment
1. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
   a. pH: 9.0 to 10.5.
   b. "P" Alkalinity: 100 to 500 ppm.
   c. Boron: 100 to 200 ppm.
   d. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
   e. Corrosion Inhibitor:
      1) Sodium Nitrate: 1000 to 1500 ppm.
      2) Molybdate: 200 to 300 ppm.
      3) Chromate: 200 to 300 ppm.
      4) Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
      5) Chromate Plus Molybdate: 50 to 100 ppm each.
   f. Soluble Copper: Maximum 0.20 ppm.
   g. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
   h. Total Suspended Solids: Maximum 10 ppm.
   i. Ammonia: Maximum 20 ppm.
   j. Free Caustic Alkalinity: Maximum 20 ppm.
   k. Microbiological Limits:

1) Total Aerobic Plate Count: Maximum 1000 organisms/ml.
2) Total Anaerobic Plate Count: Maximum 100 organisms/ml.
3) Nitrate Reducers: 100 organisms/ml.
4) Sulfate Reducers: Maximum 0 organisms/ml.
5) Iron Bacteria: Maximum 0 organisms/ml.

2. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
3. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.
4. Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:
   a. Hot-Water Heating Piping: Minimum percent ethylene, as directed by the Owner **OR** propylene, **as directed**, glycol.
   b. Chilled-Water Piping: Minimum percent ethylene, as directed by the Owner **OR** propylene, **as directed**, glycol.
   c. Dual-Temperature Heating and Cooling Water Piping: Minimum percent, as directed by the Owner ethylene **OR** propylene, **as directed**, glycol.
   d. Glycol Cooling-Water Piping: Minimum percent ethylene, as directed by the Owner. **OR** propylene, **as directed**, glycol.

I. Field Quality Control
1. Prepare hydronic piping according to ASME B31.9 and as follows:
   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   c. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
   d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
   e. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
2. Perform the following tests on hydronic piping:
   a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   b. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
   c. Isolate expansion tanks and determine that hydronic system is full of water.
   d. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
   e. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
   f. Prepare written report of testing.
3. Perform the following before operating the system:
   a. Open manual valves fully.
   b. Inspect pumps for proper rotation.
   c. Set makeup pressure-reducing valves for required system pressure.
   d. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
   e. Set temperature controls so all coils are calling for full flow.
   f. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.

g. Verify lubrication of motors and bearings.

END OF SECTION 15061f

SECTION 15061g - STEAM AND CONDENSATE PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for steam and condensate piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following for LP and HP steam and condensate piping:
   a. Pipe and fittings.
   b. Strainers.
   c. Flash tanks.
   d. Safety valves.
   e. Pressure-reducing valves.
   f. Steam traps.
   g. Thermostatic air vents and vacuum breakers.
   h. Steam and condensate meters.

C. Definitions
1. HP Systems: High-pressure piping operating at more than 15 psig (104 kPa) as required by ASME B31.1.
2. LP Systems: Low-pressure piping operating at 15 psig (104 kPa) or less as required by ASME B31.9.
3. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
4. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

D. Performance Requirements
1. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:
   a. HP Steam Piping: <**Insert psig (kPa)**.>
   b. LP Steam Piping: <**Insert psig (kPa).**>
   c. Condensate Piping: <**Insert psig (kPa)**> at 250 deg F (121 deg C).
   d. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
   e. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
   f. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
   g. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

E. Submittals
1. Product Data: For each type of the following:
   a. RTRP and RTRF with adhesive.
   b. Pressure-reducing and safety valve.
   c. Steam trap.
   d. Air vent and vacuum breaker.
   e. Flash tank.
   f. Meter.
2. Shop Drawings: Detail, 1/4 inch equals 1 foot (1:50) scale, flash tank assemblies and fabrication of pipe anchors, hangers, pipe, multiple pipes, alignment guides, and expansion joints and loops and their attachment to the building structure. Detail locations of anchors, alignment guides, and expansion joints and loops.

3. Welding certificates.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

F. Quality Assurance
1. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code - Steel."
2. Pipe Welding: Qualify processes and operators according to the following:
   a. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   b. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
3. ASME Compliance: Comply with ASME B31.1, "Power Piping" **AND/OR** ASME B31.9, "Building Services Piping", **as directed**, for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1.2 PRODUCTS

A. Copper Tube And Fittings
1. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed**.
2. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).
3. Wrought-Copper Fittings and Unions: ASME B16.22.

B. Steel Pipe And Fittings
1. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, Type, Grade, and Schedule as indicated in Part 3 piping applications articles.
2. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125, 150, and 300 as indicated in Part 3 piping applications articles.
3. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in Part 3 piping applications articles.
4. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 piping applications articles.
5. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Classes 125 and 250 as indicated in Part 3 piping applications articles; raised ground face, and bolt holes spot faced.
6. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
7. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
   a. Material Group: 1.1.
   b. End Connections: Butt welding.
   c. Facings: Raised face.
8. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.
9. Stainless-Steel Bellows, Flexible Connectors:
   a. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
   b. End Connections: Threaded or flanged to match equipment connected.
   c. Performance: Capable of 3/4-inch (20-mm) misalignment.
   d. CWP Rating: 150-psig (1035-kPa).
   e. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Fiberglass Pipe And Fittings

1. RTRP: ASTM D 2996 filament-wound pipe with tapered bell and spigot ends for adhesive joints.
2. RTRF: Compression or spray-up/contact molded fittings of same material, pressure class, and joining method as pipe.
3. Flanges: ASTM D 4024 full-face gaskets suitable for the service, minimum 1/8 inch (3.2 mm) thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.
4. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

D. Joining Materials
1. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
   a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
      1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
3. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
4. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
5. Welding Filler Metals: Comply with AWS D10.12 (AWS D10.12M) for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
6. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

E. Dielectric Fittings
1. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Insulating Material: Suitable for system fluid, pressure, and temperature.
3. Dielectric Unions:
   a. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
4. Dielectric Flanges:
   a. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
5. Dielectric-Flange Kits:
   a. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   b. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

F. Valves
1. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 15 Section "General-duty Valves For Hvac Piping".
2. Stop-Check Valves:
   a. Body and Bonnet: Malleable iron.
   b. End Connections: Flanged.
   c. Disc: Cylindrical with removable liner and machined seat.
   d. Stem: Brass alloy.
   e. Operator: Outside screw and yoke with cast-iron handwheel.
   f. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.
   g. Pressure Class: 250.

G. Strainers
1. Y-Pattern Strainers:

a. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
b. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
c. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
d. Tapped blowoff plug.
e. CWP Rating: 250-psig (1725-kPa) working steam pressure.

2. Basket Strainers:
   a. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
   b. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
   c. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
   d. CWP Rating: 250-psig (1725-kPa) working steam pressure.

H. Flash Tanks
1. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig (1035-kPa) rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

I. Safety Valves
1. Bronze **OR** Brass, **as directed**, Safety Valves:
   a. Disc Material: Forged copper alloy.
   b. End Connections: Threaded inlet and outlet.
   c. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
   d. Pressure Class: 250.
   e. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
   f. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
2. Cast-Iron Safety Valves:
   a. Disc Material: Forged copper alloy with bronze nozzle.
   b. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
   c. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
   d. Pressure Class: 250.
   e. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
   f. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
   g. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

J. Pressure-Reducing Valves
1. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.
2. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.
3. Body: Cast iron.
4. End Connections: Threaded connections for valves NPS 2 (DN 50) and smaller and flanged connections for valves NPS 2-1/2 (DN 65) and larger.
5. Trim: Hardened stainless steel.
6. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.
7. Gaskets: Non-asbestos materials.

K. Steam Traps
1. Thermostatic Traps:
   a. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
   b. Trap Type: Balanced-pressure.
   c. Bellows: Stainless steel or monel.
   d. Head and Seat: Replaceable, hardened stainless steel.
   e. Pressure Class: 125.
2. Thermodynamic Traps:
   a. Body: Stainless steel with screw-in cap.
   b. End Connections: Threaded.
   c. Disc and Seat: Stainless steel.
   d. Maximum Operating Pressure: 600 psig (4140 kPa).
3. Float and Thermostatic Traps:
   a. Body and Bolted Cap: ASTM A 126, cast iron.
   b. End Connections: Threaded.
   c. Float Mechanism: Replaceable, stainless steel.
   d. Head and Seat: Hardened stainless steel.
   e. Trap Type: Balanced pressure.
   f. Thermostatic Bellows: Stainless steel or monel.
   g. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.
   h. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
   i. Maximum Operating Pressure: 125 psig (860 kPa).
4. Inverted Bucket Traps:
   a. Body and Cap: Cast iron.
   b. End Connections: Threaded.
   c. Head and Seat: Stainless steel.
   d. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
   e. Bucket: Brass or stainless steel.
   f. Strainer: Integral stainless-steel inlet strainer within the trap body.
   g. Air Vent: Stainless-steel thermostatic vent.
   h. Pressure Rating: 250 psig (1725 kPa).

L. Thermostatic Air Vents And Vacuum Breakers
1. Thermostatic Air Vents:
   a. Body: Cast iron, bronze or stainless steel.
   b. End Connections: Threaded.
   c. Float, Valve, and Seat: Stainless steel.
   d. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
   e. Pressure Rating: 125 psig (861 kPa) **OR** 300 psig (2068 kPa), **as directed**.
   f. Maximum Temperature Rating: 350 deg F (177 deg C).
2. Vacuum Breakers:
   a. Body: Cast iron, bronze, or stainless steel.
   b. End Connections: Threaded.
   c. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
   d. O-ring Seal: EPR.
   e. Pressure Rating: 125 psig (861 kPa) **OR** 300 psig (2068 kPa), **as directed**.
   f. Maximum Temperature Rating: 350 deg F (177 deg C).

M. Steam Meters
1. Meters shall have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.
   a. Computer shall have 4 to 20-mA or 2 to 10 volt output for temperature, pressure, and contact closure for flow increments.
   b. Independent timers to store four peak flow rates and total flow.

c. Interface compatible with central workstation described in Division 15 Section "Hvac Instrumentation And Controls".
d. Microprocessor Enclosure: NEMA 250, Type 4.

2. Sensor:
   a. Venturi, of stainless-steel **OR** carbon-steel, **as directed**, construction, for insertion in pipeline between flanges. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
   b. Vortex type with stainless-steel wetted parts and wafer **OR** flange, **as directed**, connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.
   c. Spring-loaded, variable-area flowmeter type; density compensated with stainless-steel wetted parts and wafer **OR** flange, **as directed**, connections. At least 10:1 turndown with plus or minus 2 percent accuracy over full-flow range.

N. Condensate Meters
1. Body: Cast iron, bronze, or brass.
2. Turbine: Copper, brass, or stainless steel.
3. Connections: Threaded for NPS 2 (DN 50) and smaller and flanged for NPS 2-1/2 (DN 65).
4. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
   a. Computer shall have 4- to 20-mA or 2- to 10-volt output for temperature, pressure, and contact closure for flow increments.
   b. Independent timers to store four peak flow rates and total flow.
   c. Interface compatible with central workstation specified in Division 15 Section "Hvac Instrumentation And Controls".
   d. Microprocessor Enclosure: NEMA 250, Type 4.
5. Pressure Rating: Atmospheric.
6. Maximum Temperature Rating: 250 deg F (121 deg C).

1.3 EXECUTION

A. LP Steam Piping Applications
1. LP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40 **OR** 80, **as directed**, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. LP Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 **OR** 80, **as directed**, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
3. LP Steam Piping, NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
4. LP Steam Piping, NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
5. Condensate piping above grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:
   a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
   b. RTRP and RTRF with adhesive or flanged joints.
6. Condensate piping above grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
   a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   b. RTRP and RTRF with adhesive or flanged joints.
7. Condensate piping below grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:

a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
b. RTRP and RTRF with adhesive or flanged joints.

8. Condensate piping below grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
   a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   b. RTRP and RTRF with adhesive or flanged joints.

B. HP Steam Piping Applications

1. HP Steam Piping, NPS 2 (DN 50) and Smaller: Schedule 40 **OR** 80, **as directed**, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
2. HP Steam Piping, NPS 2-1/2 through NPS 12 (DN 65 through DN 300): Schedule 40 **OR** 80, **as directed**, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
3. HP Steam Piping, NPS 14 through NPS 18 (DN 350 through DN 450): Schedule 30, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
4. HP Steam Piping, NPS 20 (DN 500) and Larger: Schedule 20, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
5. Condensate piping above grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:
   a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
   b. RTRP and RTRF with adhesive or flanged joints.
6. Condensate piping above grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
   a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   b. RTRP and RTRF with adhesive or flanged joints.
7. Condensate piping below grade, NPS 2 (DN 50) and smaller, shall be either of the following, **as directed**:
   a. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.
   b. RTRP and RTRF with adhesive or flanged joints.
8. Condensate piping below grade, NPS 2-1/2 (DN 65) and larger, shall be either of the following, **as directed**:
   a. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
   b. RTRP and RTRF with adhesive or flanged joints.

C. Ancillary Piping Applications

1. Makeup-water piping installed above grade shall be either of the following, **as directed**:
   a. Drawn-temper copper tubing, wrought-copper fittings, and soldered **OR** brazed, **as directed**, joints.
   b. Schedule 40 **OR** 80, **as directed**, CPVC plastic pipe and fittings, and solvent welded joints.
2. Makeup-Water Piping Installed below Grade and within Slabs: Annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
3. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
4. Air-Vent Piping:
   a. Inlet: Same as service where installed.
   b. Outlet: Type K (A) annealed-temper copper tubing with soldered or flared joints.
5. Vacuum-Breaker Piping: Outlet, same as service where installed.
6. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

D. Valve Applications

1. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
2. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Use indicated piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
5. Install piping to permit valve servicing.
6. Install piping free of sags and bends.
7. Install fittings for changes in direction and branch connections.
8. Install piping to allow application of insulation.
9. Select system components with pressure rating equal to or greater than system operating pressure.
10. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
11. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
12. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.
13. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.
14. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
15. Install branch connections to mains using mechanically formed, **as directed**, tee fittings in main pipe, with the branch connected to top of main pipe.
16. Install valves according to Division 15 Section "General-duty Valves For Hvac Piping".
17. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
18. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
19. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).
20. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 15 Section "Expansion Fittings And Loops For Hvac Piping".
21. Identify piping as specified in Division 15 Section "Identification For Hvac Piping And Equipment".
22. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
    a. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 300 feet (90 m).
    b. Size drip legs same size as main. In steam mains NPS 6 (DN 150) and larger, drip leg size can be reduced, but to no less than NPS 4 (DN 100).
23. Flash Tank:

a. Pitch condensate piping down toward flash tank.
b. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
c. Install thermostatic air vent at tank top.
d. Install safety valve at tank top.
e. Install full-port ball valve, and swing check valve on condensate outlet.
f. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three times the calculated heat load.
g. Install pressure gage on low-pressure steam outlet according to Division 15 Section "Meters And Gages For Hvac Piping".

F. Steam-Trap Installation
1. Install steam traps in accessible locations as close as possible to connected equipment.
2. Install full-port ball valve, strainer, and union upstream from trap; install union, check valve, and full-port ball valve downstream from trap unless otherwise indicated.

G. Pressure-Reducing Valve Installation
1. Install pressure-reducing valves in accessible location for maintenance and inspection.
2. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.
3. Install gate valves on both sides of pressure-reducing valves.
4. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections respectively.
5. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Division 15 Section "Meters And Gages For Hvac Piping".
6. Install strainers upstream for pressure-reducing valve.
7. Install safety valve downstream from pressure-reducing valve station.

H. Steam Or Condensate Meter Installation
1. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's instructions.
2. Provide data acquisition wiring. Refer to Division 15 Section "Hvac Instrumentation And Controls".

I. Safety Valve Installation
1. Install safety valves according to ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**
2. Pipe safety-valve discharge without valves to atmosphere outside the building.
3. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
4. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2 (DN 65).

J. Hangers And Supports
1. Install hangers and supports according to Division 15 Section "Hangers And Supports For Hvac Piping And Equipment". Comply with requirements below for maximum spacing.
2. Seismic restraints are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install the following pipe attachments:
   a. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
   b. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
   c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
   d. Spring hangers to support vertical runs.
4. Install hangers with the following maximum spacing and minimum rod sizes:
   a. NPS 3/4 (DN 20): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).

b. NPS 1 (DN 25): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).
c. NPS 1-1/2 (DN 40): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
d. NPS 2 (DN 50): Maximum span, 13 feet (4 m); minimum rod size, 3/8 inch (10 mm).
e. NPS 2-1/2 (DN 65): Maximum span, 14 feet (4.3 m); minimum rod size, 3/8 inch (10 mm).
f. NPS 3 (DN 80): Maximum span, 15 feet (4.6 m); minimum rod size, 3/8 inch (10 mm).
g. NPS 4 (DN 100): Maximum span, 17 feet (5.2 m); minimum rod size, 1/2 inch (13 mm).
h. NPS 6 (DN 150): Maximum span, 21 feet (6.4 m); minimum rod size, 1/2 inch (13 mm).
i. NPS 8 (DN 200): Maximum span, 24 feet (7.3 m); minimum rod size, 5/8 inch (16 mm).
j. NPS 10 (DN 250): Maximum span, 26 feet (8 m); minimum rod size, 3/4 inch (19 mm).
k. NPS 12 (DN 300): Maximum span, 30 feet (9.1 m); minimum rod size, 7/8 inch (22 mm).
l. NPS 14 (DN 350): Maximum span, 32 feet (9.8 m); minimum rod size, 1 inch (25 mm).
m. NPS 16 (DN 400): Maximum span, 35 feet (10.7 m); minimum rod size, 1 inch (25 mm).
n. NPS 18 (DN 450): Maximum span, 37 feet (11.3 m); minimum rod size, 1-1/4 inches (32 mm).
o. NPS 20 (DN 500): Maximum span, 39 feet (11.9 m); minimum rod size, 1-1/4 inches (32 mm).

5. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
   a. NPS 1/2 (DN 15): Maximum span, 4 feet (1.2 m); minimum rod size, 1/4 inch (6.4 mm).
   b. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
   c. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
   d. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
   e. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
   f. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
   g. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
6. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.
7. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

K. Pipe Joint Construction
1. Join pipe and fittings according to the following requirements and Division 15 specifying piping systems.
2. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube ends. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
6. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Welded Joints: Construct joints according to AWS D10.12 (AWS D10.12M), using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
8. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
9. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

L. Terminal Equipment Connections

1. Size for supply and return piping connections shall be the same as or larger than equipment connections.
2. Install traps and control valves in accessible locations close to connected equipment.
3. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
4. Install vacuum breakers downstream from control valve, close to coil inlet connection.
5. Install a drip leg at coil outlet.

M. Field Quality Control
1. Prepare steam and condensate piping according to ASME B31.1, "Power Piping" **AND/OR** ASME B31.9, "Building Services Piping," **as directed,** and as follows:
   a. Leave joints, including welds, uninsulated and exposed for examination during test.
   b. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
   c. Flush system with clean water. Clean strainers.
   d. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
2. Perform the following tests on steam and condensate piping:
   a. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
   b. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
   c. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
3. Prepare written report of testing.

END OF SECTION 15061g

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SECTION 15061h - REFRIGERANT PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for refrigerant piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes refrigerant piping used for air-conditioning applications.

C. Performance Requirements
1. Line Test Pressure for Refrigerant R-22:
   a. Suction Lines for Air-Conditioning Applications: 185 psig (1276 kPa).
   b. Suction Lines for Heat-Pump Applications: 325 psig (2241 kPa).
   c. Hot-Gas and Liquid Lines: 325 psig (2241 kPa).
2. Line Test Pressure for Refrigerant R-134a:
   a. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
   b. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
   c. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).
3. Line Test Pressure for Refrigerant R-407C:
   a. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
   b. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
   c. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).
4. Line Test Pressure for Refrigerant R-410A:
   a. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
   b. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
   c. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

D. Submittals
1. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
   a. Thermostatic expansion valves.
   b. Solenoid valves.
   c. Hot-gas bypass valves.
   d. Filter dryers.
   e. Strainers.
   f. Pressure-regulating valves.
2. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
   a. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).
   b. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
3. Welding certificates.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

E. Quality Assurance
1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
3. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

F. Product Storage And Handling
1. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.2 PRODUCTS

A. Copper Tube And Fittings
1. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B) **OR** ASTM B 280, Type ACR, **as directed**.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
5. Brazing Filler Metals: AWS A5.8.
6. Flexible Connectors:
   a. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
   b. End Connections: Socket ends.
   c. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
   d. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
   e. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Steel Pipe And Fittings
1. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.
2. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
3. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.
4. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
5. Flanged Unions:
   a. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.
   b. Gasket: Fiber asbestos free.
   c. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
   d. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
   e. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
   f. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
   g. Maximum Operating Temperature: 330 deg F (165 deg C).
6. Flexible Connectors:
   a. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
   b. End Connections:
      1) NPS 2 (DN 50) and Smaller: With threaded-end connections.
      2) NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.

c. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
d. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
e. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Valves And Specialties
1. Diaphragm Packless Valves:
a. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
b. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
c. Operator: Rising stem and hand wheel.
d. Seat: Nylon.
e. End Connections: Socket, union, or flanged.
f. Working Pressure Rating: 500 psig (3450 kPa).
g. Maximum Operating Temperature: 275 deg F (135 deg C).
2. Packed-Angle Valves:
a. Body and Bonnet: Forged brass or cast bronze.
b. Packing: Molded stem, back seating, and replaceable under pressure.
c. Operator: Rising stem.
d. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
e. Seal Cap: Forged-brass or valox hex cap.
f. End Connections: Socket, union, threaded, or flanged.
g. Working Pressure Rating: 500 psig (3450 kPa).
h. Maximum Operating Temperature: 275 deg F (135 deg C).
3. Check Valves:
a. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
b. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
c. Piston: Removable polytetrafluoroethylene seat.
d. Closing Spring: Stainless steel.
e. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
f. End Connections: Socket, union, threaded, or flanged.
g. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
h. Working Pressure Rating: 500 psig (3450 kPa).
i. Maximum Operating Temperature: 275 deg F (135 deg C).
4. Service Valves:
a. Body: Forged brass with brass cap including key end to remove core.
b. Core: Removable ball-type check valve with stainless-steel spring.
c. Seat: Polytetrafluoroethylene.
d. End Connections: Copper spring.
e. Working Pressure Rating: 500 psig (3450 kPa).
5. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.
a. Body and Bonnet: Plated steel.
b. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
c. Seat: Polytetrafluoroethylene.
d. End Connections: Threaded.
e. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24 **OR** 115 **OR** 208, **as directed**,-V ac coil.
f. Working Pressure Rating: 400 psig (2760 kPa).
g. Maximum Operating Temperature: 240 deg F (116 deg C).
h. Manual operator.
6. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
b. Piston, Closing Spring, and Seat Insert: Stainless steel.
c. Seat Disc: Polytetrafluoroethylene.
d. End Connections: Threaded.

e. Working Pressure Rating: 400 psig (2760 kPa).
f. Maximum Operating Temperature: 240 deg F (116 deg C).

7. Thermostatic Expansion Valves: Comply with ARI 750.
   a. Body, Bonnet, and Seal Cap: Forged brass or steel.
   b. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   c. Packing and Gaskets: Non-asbestos.
   d. Capillary and Bulb: Copper tubing filled with refrigerant charge.
   e. Suction Temperature: 40 deg F (4.4 deg C).
   f. Superheat: Adjustable **OR** Nonadjustable, **as directed**.
   g. Reverse-flow option (for heat-pump applications).
   h. End Connections: Socket, flare, or threaded union.
   i. Working Pressure Rating: 700 psig (4820 kPa) **OR** 450 psig (3100 kPa), **as directed**.
8. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
   a. Body, Bonnet, and Seal Cap: Ductile iron or steel.
   b. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
   c. Packing and Gaskets: Non-asbestos.
   d. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
   e. Seat: Polytetrafluoroethylene.
   f. Equalizer: Internal **OR** External, **as directed**.
   g. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 24 **OR** 115 **OR** 208, **as directed**,-V ac coil.
   h. End Connections: Socket.
   i. Set Pressure: as directed by the Owner.
   j. Throttling Range: Maximum 5 psig (34 kPa).
   k. Working Pressure Rating: 500 psig (3450 kPa).
   l. Maximum Operating Temperature: 240 deg F (116 deg C).
9. Straight-Type Strainers:
   a. Body: Welded steel with corrosion-resistant coating.
   b. Screen: 100-mesh stainless steel.
   c. End Connections: Socket or flare.
   d. Working Pressure Rating: 500 psig (3450 kPa).
   e. Maximum Operating Temperature: 275 deg F (135 deg C).
10. Angle-Type Strainers:
   a. Body: Forged brass or cast bronze.
   b. Drain Plug: Brass hex plug.
   c. Screen: 100-mesh monel.
   d. End Connections: Socket or flare.
   e. Working Pressure Rating: 500 psig (3450 kPa).
   f. Maximum Operating Temperature: 275 deg F (135 deg C).
11. Moisture/Liquid Indicators:
   a. Body: Forged brass.
   b. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
   c. Indicator: Color coded to show moisture content in ppm.
   d. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
   e. End Connections: Socket or flare.
   f. Working Pressure Rating: 500 psig (3450 kPa).
   g. Maximum Operating Temperature: 240 deg F (116 deg C).
12. Replaceable-Core Filter Dryers: Comply with ARI 730.
   a. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
   b. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   c. Desiccant Media: Activated alumina **OR** charcoal, **as directed**.
   d. Designed for reverse flow (for heat-pump applications).
   e. End Connections: Socket.

f. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
g. Maximum Pressure Loss: 2 psig (14 kPa).
h. Rated Flow: as directed by the Owner.
i. Working Pressure Rating: 500 psig (3450 kPa).
j. Maximum Operating Temperature: 240 deg F (116 deg C).

13. Permanent Filter Dryers: Comply with ARI 730.
    a. Body and Cover: Painted-steel shell.
    b. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
    c. Desiccant Media: Activated alumina **OR** charcoal, **as directed**.
    d. Designed for reverse flow (for heat-pump applications).
    e. End Connections: Socket.
    f. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
    g. Maximum Pressure Loss: 2 psig (14 kPa).
    h. Rated Flow: as directed by the Owner.
    i. Working Pressure Rating: 500 psig (3450 kPa).
    j. Maximum Operating Temperature: 240 deg F (116 deg C).
14. Mufflers:
    a. Body: Welded steel with corrosion-resistant coating.
    b. End Connections: Socket or flare.
    c. Working Pressure Rating: 500 psig (3450 kPa).
    d. Maximum Operating Temperature: 275 deg F (135 deg C).
15. Receivers: Comply with ARI 495.
    a. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
    b. Comply with UL 207; listed and labeled by an NRTL.
    c. Body: Welded steel with corrosion-resistant coating.
    d. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
    e. End Connections: Socket or threaded.
    f. Working Pressure Rating: 500 psig (3450 kPa).
    g. Maximum Operating Temperature: 275 deg F (135 deg C).
16. Liquid Accumulators: Comply with ARI 495.
    a. Body: Welded steel with corrosion-resistant coating.
    b. End Connections: Socket or threaded.
    c. Working Pressure Rating: 500 psig (3450 kPa).
    d. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Refrigerants
1. ASHRAE 34, R-22: Monochlorodifluoromethane.
2. ASHRAE 34, R-134a: Tetrafluoroethane.
3. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
4. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

1.3 EXECUTION

A. Piping Applications For Refrigerant R-22
1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
   OR
   Suction Lines NPS 4 (DN 100) and Smaller **OR** NPS 2 to NPS 4 (DN 50 to DN 100), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
   OR
   Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B, **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.
   OR
   Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:
   a. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
      OR
      NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR **OR** L (B), **as directed,** drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
   b. NPS 2 to NPS 3 (DN 50 to DN 80): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
   c. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.
3. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.
   OR
   Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.
   OR
   Safety-Relief-Valve Discharge Piping:
   a. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
      OR
      NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed joints.
   b. NPS 2 to NPS 3 (DN 50 to DN 80): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
   c. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

B. Piping Applications For Refrigerant R-134a
1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed,** joints.
   OR
   Suction Lines NPS 4 (DN 100) and Smaller **OR** NPS 2 to NPS 4 (DN 50 to DN 100), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed,** joints.
2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed,** joints.
   OR
   Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.
   OR
   Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:
   a. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed,** joints.
      OR

NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

b. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

3. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

OR

Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

OR

Safety-Relief-Valve Discharge Piping:

a. NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

b. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

C. Piping Applications For Refrigerant R-407c

1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings

OR

Suction Lines NPS 4 (DN 100) and Smaller **OR** NPS 2 to NPS 4 (DN 50 to DN 100), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:

a. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

NPS 1 (DN 25) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

b. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

c. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

3. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

OR

Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B**)**, **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

OR

Safety-Relief-Valve Discharge Piping:

a. NPS 1 (DN 25) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered joints.

OR

NPS 1 (DN 25) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

b. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

c. NPS 4 (DN 100): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Piping Applications For Refrigerant R-410a

1. Suction Lines NPS 1-1/2 (DN 40) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Suction Lines NPS 3-1/2 (DN 90) and Smaller **OR** NPS 2 to NPS 3-1/2 (DN 50 to DN 90), **as directed**, for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** L (B), **as directed,** drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Suction Lines NPS 4 (DN 100) and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with soldered joints.

2. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed** Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**:

a. NPS 5/8 (DN 18) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

b. NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

c. NPS 1-1/4 (DN 32) and Smaller: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.

d. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

OR

Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications, **as directed**, NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.

3. Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR

Safety-Relief-Valve Discharge Piping: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.

OR
Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
OR
Safety-Relief-Valve Discharge Piping: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.
OR
Safety-Relief-Valve Discharge Piping:
a. NPS 5/8 (DN 18) and Smaller: Copper, Type ACR **OR** L (B), **as directed**, annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
b. NPS 3/4 to NPS 1 (DN 20 to DN 25) and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed **OR** soldered, **as directed**, joints.
c. NPS 1-1/4 (DN 32) and Smaller: Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony soldered joints.
d. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): Copper, Type ACR **OR** K (A) **OR** L (B), **as directed**, drawn-temper tubing and wrought-copper fittings with Alloy HB soldered joints.

OR
Safety-Relief-Valve Discharge Piping NPS 2 to NPS 4 (DN 50 to DN 100): Schedule 40, black-steel and wrought-steel fittings with welded joints.

E. Valve And Specialty Applications
1. Install diaphragm packless **OR** packed-angle, **as directed**, valves in suction and discharge lines of compressor.
2. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
3. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
4. Except as otherwise indicated, install diaphragm packless **OR** packed-angle, **as directed**, valves on inlet and outlet side of filter dryers.
5. Install a full-sized, three-valve bypass around filter dryers.
6. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
7. Install thermostatic expansion valves as close as possible to distributors on evaporators.
   a. Install valve so diaphragm case is warmer than bulb.
   b. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
   c. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
8. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
9. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
10. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
    a. Solenoid valves.
    b. Thermostatic expansion valves.
    c. Hot-gas bypass valves.
    d. Compressor.
11. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor, **as directed**.
12. Install receivers sized to accommodate pump-down charge.
13. Install flexible connectors at compressors.

F. Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
2. Install refrigerant piping according to ASHRAE 15.
3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping adjacent to machines to allow service and maintenance.
7. Install piping free of sags and bends.
8. Install fittings for changes in direction and branch connections.
9. Select system components with pressure rating equal to or greater than system operating pressure.
10. Refer to Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation" for solenoid valve controllers, control wiring, and sequence of operation.
11. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
12. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors And Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
13. Install refrigerant piping in protective conduit where installed belowground.
14. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
15. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.
    c. Install traps and double risers to entrain oil in vertical runs.
    d. Liquid lines may be installed level.
16. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
17. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
    a. Shot blast the interior of piping.
    b. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
    c. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
    d. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
    e. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
    f. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
18. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
19. Seal penetrations through fire and smoke barriers according to Division 07 Section "Through-penetration Firestop Systems".
20. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
21. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

22. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
23. Identify refrigerant piping and valves according to Division 15 Section "Identification For Hvac Piping And Equipment".

G. Pipe Joint Construction
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
4. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
6. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
7. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
8. Welded Joints: Construct joints according to AWS D10.12/D10.12M.
9. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Hangers And Supports
1. Hanger, support, and anchor products are specified in Division 15 Section "Hangers And Supports For Hvac Piping And Equipment".
2. Install the following pipe attachments:
   a. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
   b. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
   c. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
   d. Spring hangers to support vertical runs.
   e. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
3. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   a. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   b. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
   c. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
   d. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
   e. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
   f. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
   g. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
   h. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
   i. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

4. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
   a. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
   b. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).
   c. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).
   d. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
5. Support multifloor vertical runs at least at each floor.

I. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
   a. Comply with ASME B31.5, Chapter VI.
   b. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
   c. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
      1) Fill system with nitrogen to the required test pressure.
      2) System shall maintain test pressure at the manifold gage throughout duration of test.
      3) Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
      4) Remake leaking joints using new materials, and retest until satisfactory results are achieved.

J. System Charging
1. Charge system using the following procedures:
   a. Install core in filter dryers after leak test but before evacuation.
   b. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
   c. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
   d. Charge system with a new filter-dryer core in charging line.

K. Adjusting
1. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
2. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
3. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
4. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
   a. Open shutoff valves in condenser water circuit.
   b. Verify that compressor oil level is correct.
   c. Open compressor suction and discharge valves.
   d. Open refrigerant valves except bypass valves that are used for other purposes.
   e. Check open compressor-motor alignment and verify lubrication for motors and bearings.
5. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 15061h

SECTION 15061i - FACILITY FUEL-OIL PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for facility fuel-oil piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes fuel-oil, fuel-oil and diesel-fuel-oil, and diesel-fuel-oil distribution systems and the following:
   a. Pipes, tubes, and fittings.
   b. Piping and tubing joining materials.
   c. Piping specialties.
   d. Valves.
   e. Vertical, steel, fuel-oil ASTs.
   f. Horizontal, steel, fuel-oil ASTs.
   g. Containment-dike, steel, fuel-oil ASTs.
   h. Insulated, steel, fuel-oil ASTs.
   i. Concrete-vaulted, steel, fuel-oil ASTs.
   j. Steel, fuel-oil USTs with STI-P3.
   k. Composite, steel, fuel-oil USTs.
   l. Jacketed, steel, fuel-oil USTs.
   m. FRP fuel-oil USTs.
   n. Fuel-oil AST accessories.
   o. Fuel-oil UST accessories.
   p. Fuel-oil storage tank piping specialties.
   q. Fuel-oil storage tank pumps.
   r. Fuel-transfer pumps.
   s. Fuel maintenance system.
   t. Liquid-level gage system.
   u. Leak-detection and monitoring system.
   v. Mechanical sleeve seals.
   w. Grout.
   x. Concrete bases.

C. Definitions
1. AST: Aboveground storage tank.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
5. FPM: Vinylidene fluoride-hexafluoropropylene copolymer rubber.
6. FRP: Glass-fiber-reinforced plastic.
7. UST: Underground storage tank.

D. Performance Requirements
1. Maximum Operating-Pressure Ratings: 3-psig (21-kPa) fuel-oil supply pressure at oil-fired appliances.

2. Delegated Design: Design restraint and anchors for fuel-oil piping, ASTs, and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Seismic Performance: Factory-installed support attachments for AST shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event, **as directed**."

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility fuel-oil piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For fuel-oil piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Detail fabrication and assembly of anchors and seismic restraints.
   b. Design Calculations: Calculate requirements for selecting seismic restraints.
   c. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.
4. Seismic Qualification Certificates: For ASTs, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Brazing certificates.
6. Welding certificates.
7. Field quality-control reports.
8. Operation and Maintenance Data.
9. Warranty: Sample of special warranty.

F. Quality Assurance
1. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
2. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.
6. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil storage tanks and monitoring of tanks and piping.

G. Delivery, Storage, And Handling
1. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

3. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.
4. Store PE pipes and valves protected from direct sunlight.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-oil storage tanks and flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.
   a. Storage Tanks:
      1) Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding 150 deg F (66 deg C):
         a) Structural failures including cracking, breakup, and collapse.
         b) Corrosion failure including external and internal corrosion of steel tanks.
      2) Warranty Period: 30 years from date of Substantial Completion.
   b. Flexible, Double-Containment Piping and Related Equipment:
      1) Failures due to defective materials or workmanship for materials installed together, including piping, dispenser sumps, entry boots, and sump mounting adapters.
      2) Warranty Period: 10 **OR** 30, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings
1. See Part 1.3 piping schedule articles for where pipes, tubes, fittings, and joining materials are applied in various services.
2. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
   a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
   b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
   c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
   d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
      1) Material Group: 1.1.
      2) End Connections: Threaded or butt welding to match pipe.
      3) Lapped Face: Not permitted underground.
      4) Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
      5) Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.
   e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
      1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
3. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**.
   a. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
   b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
      1) Gasket Material: Asbestos free, ASME B16.20, metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
      2) Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.
4. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K (ASTM B 88M, Type A) **OR** ASTM B 88, Type L (ASTM B 88M, Type B), **as directed**.
   a. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
   b. Flare Fittings: Comply with ASME B16.26 and SAE J513.
      1) Copper fittings with long nuts.
      2) Metal-to-metal compression seal without gasket.
      3) Dryseal threads complying with ASME B1.20.3.

B. Double-Containment Pipe And Fittings
   1. Flexible, Double-Containment Piping: Comply with UL 971.
      a. Pipe Materials: PVDF complying with ASTM D 3222 for carrier pipe with mechanical couplings to seal carrier, and PE pipe complying with ASTM D 4976 for containment piping.
      b. Fiberglass **OR** PE, **as directed**, sumps.
      c. Watertight sump entry boots, pipe adapters with test ports and tubes, coaxial fittings, and couplings.
      d. Minimum Operating Pressure Rating: 10 psig (69 kPa).
      e. Plastic to Steel Pipe Transition Fittings: Factory-fabricated fittings with plastic end matching or compatible with carrier piping, and steel pipe end complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
      f. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.
   2. Rigid, Double-Containment Piping: Comply with UL 971.
      a. RTRP: ASTM D 2996 or ASTM D 2997 carrier and containment piping and mechanical couplings to seal carrier and containment piping or individually bonded joints.
         1) Minimum Operating-Pressure Rating for RTRP NPS 2 and NPS 3 (DN 50 and DN 80): 150 psig (1035 kPa).
         2) Minimum Operating-Pressure Rating for RTRP NPS 4 and NPS 6 (DN 100 and DN 150): 125 psig (860 kPa). Compliance with UL 971 is not required for NPS 6 (DN 150) and larger piping.
         3) Fittings: RTRF complying with ASTM D 2996 or ASTM D 2997, and made by RTRP manufacturer; watertight sump entry boots, termination, or other end fittings.
      b. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

C. Piping Specialties
   1. Flexible Connectors: Comply with UL 567.
      a. Metallic Connectors:
         1) Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
         2) Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
         3) Minimum Operating Pressure: 150 psig (1035 kPa).
         4) End Connections: Socket, flanged, or threaded end to match connected piping.
         5) Maximum Length: 30 inches (762 mm).
         6) Swivel end, 50-psig (345-kPa) maximum operating pressure.
         7) Factory-furnished anode.
      b. Nonmetallic Connectors:
         1) Listed and labeled for underground applications by an NRTL acceptable to authorities having jurisdiction.
         2) PFTE bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
         3) Minimum Operating Pressure: 150 psig (1035 kPa).
         4) End Connections: Socket, flanged, or threaded end to match connected piping.
         5) Maximum Length: 30 inches (762 mm).
         6) Swivel end, 50-psig (345-kPa) maximum operating pressure.
         7) Factory-furnished anode.
   2. Y-Pattern Strainers:
      a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
      b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.

c. Strainer Screen: 60 **OR** 80, **as directed**,-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
d. CWP Rating: 125 psig (860 kPa).

3. Basket Strainers:
   a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
   b. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
   c. Strainer Screen: 60 **OR** 80, **as directed**,-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
   d. CWP Rating: 125 psig (860 kPa).
4. T-Pattern Strainers:
   a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
   b. End Connections: Grooved ends.
   c. Strainer Screen: 60 **OR** 80, **as directed**,-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
   d. CWP Rating: 750 psig (5170 kPa).
5. Manual Air Vents:
   a. Body: Bronze.
   b. Internal Parts: Nonferrous.
   c. Operator: Screwdriver or thumbscrew.
   d. Inlet Connection: NPS 1/2 (DN 15).
   e. Discharge Connection: NPS 1/8 (DN 6).
   f. CWP Rating: 150 psig (1035 kPa).
   g. Maximum Operating Temperature: 225 deg F (107 deg C).

D. Joining Materials
1. Joint Compound and Tape: Suitable for fuel oil.
2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
3. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.
4. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.

E. Manual Fuel-Oil Shutoff Valves
1. See valve schedule in Part 1.3 for where each valve type is applied in various services.
2. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller for Liquid Service: Comply with UL 842.
   a. CWP Rating: 125 psig (860 kPa).
   b. Threaded Ends: Comply with ASME B1.20.1.
   c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   d. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
   e. Service Mark: Initials "WOG" shall be permanently marked on valve body.
3. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with UL 842.
   a. CWP Rating: 125 psig (860 kPa).
   b. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   c. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
   d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
4. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
   a. Body: Bronze, complying with ASTM B 584.
   b. Ball: Chrome-plated brass.
   c. Stem: Bronze; blowout proof.
   d. Seats: Reinforced TFE; blowout proof.
   e. Packing: Separate packnut with adjustable-stem packing threaded ends.

f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
g. CWP Rating: 600 psig (4140 kPa).
h. Service Mark: Initials "WOG" shall be permanently marked on valve body.

5. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
   a. Body: Bronze, complying with ASTM B 584.
   b. Ball: Chrome-plated bronze.
   c. Stem: Bronze; blowout proof.
   d. Seats: Reinforced TFE; blowout proof.
   e. Packing: Threaded-body packnut design with adjustable-stem packing.
   f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
   g. CWP Rating: 600 psig (4140 kPa).
   h. Service Mark: Initials "WOG" shall be permanently marked on valve body.
6. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
   a. Body: Bronze, complying with ASTM B 584.
   b. Ball: Chrome-plated bronze.
   c. Stem: Bronze; blowout proof.
   d. Seats: Reinforced TFE.
   e. Packing: Threaded-body packnut design with adjustable-stem packing.
   f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
   g. CWP Rating: 600 psig (4140 kPa).
   h. Service Mark: Initials "WOG" shall be permanently marked on valve body.

F. Specialty Valves
1. Pressure Relief Valves: Comply with UL 842.
   a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
   b. Body: Brass, bronze, or cast steel.
   c. Springs: Stainless steel, interchangeable.
   d. Seat and Seal: Nitrile rubber.
   e. Orifice: Stainless steel, interchangeable.
   f. Factory-Applied Finish: Baked enamel.
   g. Maximum Inlet Pressure: 150 psig (1035 kPa).
   h. Relief Pressure Setting: 60 psig (414 kPa).
2. Oil Safety Valves: Comply with UL 842.
   a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
   b. Body: Brass, bronze, or cast steel.
   c. Springs: Stainless steel.
   d. Seat and Diaphragm: Nitrile rubber.
   e. Orifice: Stainless steel, interchangeable.
   f. Factory-Applied Finish: Baked enamel.
   g. Manual override port.
   h. Maximum Inlet Pressure: 60 psig (414 kPa).
   i. Maximum Outlet Pressure: 3 psig (21 kPa).
3. Emergency Shutoff Valves: Comply with UL 842.
   a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
   b. Single **OR** Double, **as directed**, poppet valve.
   c. Body: ASTM A 126, cast iron.
   d. Disk: FPM.
   e. Poppet Spring: Stainless steel.
   f. Stem: Plated brass.
   g. O-Ring: FPM.
   h. Packing Nut: PTFE-coated brass.
   i. Fusible link to close valve at 165 deg F (74 deg C).

j. Thermal relief to vent line pressure buildup due to fire.
k. Air test port.
l. Maximum Operating Pressure: 0.5 psig (3.45 kPa).

4. Mechanical Leak Detector: Comply with UL 842.
   a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
   b. Body: ASTM A 126, cast iron.
   c. O-Rings: Elastomeric compatible with fuel oil.
   d. Piston and Stem Seals: PTFE.
   e. Stem and Spring: Stainless steel.
   f. Piston Cylinder: Burnished brass.
   g. Indicated Leak Rate: Maximum 3 gph (3 mL/s) at 10 psig (69 kPa).
   h. Leak Indication: Reduced flow.

G. Vertical, Steel, Fuel-Oil AST
1. Description:
   a. UL 142, single-wall, vertical, steel tank.
   b. UL 142 and STI F921, **as directed**, double-wall, vertical, steel tank; with primary- and secondary-containment walls and interstitial space.
2. Construction: Fabricated with welded, carbon steel suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and maintained temperature up to 150 deg F (66 deg C).

H. Horizontal, Steel, Fuel-Oil AST
1. Description:
   a. UL 142, single-wall, horizontal, steel tank.
   b. UL 142 and STI F921, **as directed**, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and interstitial space.
2. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to 150 deg F (66 deg C).
3. Supports:
   a. Manufacturer's standard structural steel welded to tank.
   b. Manufacturer's standard type and number, steel or cast-iron cradles, for field installation.

I. Containment-Dike, Steel, Fuel-Oil AST
1. Description: UL 142 and STI F911, single-wall, horizontal, steel tank; with open or enclosed **OR** enclosed, **as directed**, secondary-containment dike with capacity greater than tank capacity.
2. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to 150 deg F (66 deg C).

J. Insulated, Steel, Fuel-Oil AST
1. Description: UL 142 and UL 2085 **OR** UL 142, UL 2085, and STI F941, **as directed**, thermally insulated and fire-resistant, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.
2. Construction: Fabricated with welded, carbon steel and insulation; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.

K. Concrete-Vaulted, Steel, Fuel-Oil AST
1. Description: UL 142 and UL 2085 **OR** UL 142, UL 2085, and STI F941, **as directed**; thermally insulated, fire-resistant and protected, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.

2. Construction: Fabricated with welded, carbon steel and insulation and encased in concrete that will protect from bullets; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.

L. Steel, Fuel-Oil UST With STI-P3
1. Description: UL 58 and STI P3, double-wall, horizontal, steel tank; with cathodic protection and electrical isolation.
   a. Containment Method: STI-P3, Type I, with primary and secondary walls in contact **OR** Type II, with interstitial space, **as directed**.
2. Construction: Fabricated with welded steel; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
   a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
   b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
   c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).
3. Corrosion-Protection System: Protect tank and factory-installed piping by engineered and installed corrosion-protection system according to STI P3, with means of monitoring cathodic protection.

M. Composite, Steel, Fuel-Oil UST
1. Description: UL 58, double-wall, horizontal, composite tank; with coating complying with UL 1746 and STI F894.
   a. Containment Method: STI F894, Type I, with primary and secondary walls in contact **OR** Type II, with interstitial space, **as directed**.
2. Construction: Fabricated with welded steel and factory coating according to UL 1746 and STI F894; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
   a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
   b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
   c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

N. Jacketed, Steel, Fuel-Oil UST
1. Description: Jacketed, horizontal, steel tank; complying with UL 58, and with plastic or fiberglass jacket and corrosion-protection system according to UL 1746 and STI F922, **as directed**.
2. Construction: Tank fabricated with welded carbon steel, and jacket fabricated with plastic or fiberglass and vacuum-sealed interstitial space; suitable for operation at atmospheric pressure and with integral leak-detection device. Tank fabricated for the following loads:
   a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
   b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
   c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

O. FRP Fuel-Oil UST
1. Description: Horizontal, FRP UST; UL 1316, double wall, with interstitial space and integral, hydrostatic, leak-detection and monitoring system, **as directed**.
2. Construction: Fabricated with fiberglass-reinforced polyester resins; suitable for operation at atmospheric pressure; fabricated for the following loads:
   a. Depth of Bury: 3 feet (1 m) from top of tank to finished surface.
   b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.

c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb (14 515 kg).

P. Shop Painting Of AST
1. Apply manufacturer's standard prime coat to exterior steel surface of AST and supports.
2. Prepare exterior steel surface of AST and tank supports.
3. Shop Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 **OR** SSPC-SP 10/NACE No. 2, **as directed**.
4. After cleaning, remove dust or residue from cleaned surfaces.
5. If surface develops rust before prime coat is applied, repeat surface preparation.
6. Apply manufacturer's standard prime coat to shop-cleaned, dry surface same day as surface preparation.
7. Apply manufacturer's standard two-component, epoxy finish coats.

Q. Fuel-Oil AST Accessories
1. Tank Manholes (for horizontal tanks and some vertical tanks): 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed; centered on top of tank.
2. Tank Manholes (for vertical tanks): 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed; on top and at side of tank.
3. For Horizontal Tanks: Threaded pipe connection fittings on top of tank, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.
4. For Vertical Tanks: Threaded pipe connection fittings on top or sides of tank as indicated, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.
5. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
6. Lifting Lugs: For handling and installation.
7. Ladders (for horizontal tanks and some vertical tanks): Carbon-steel ladder inside tank, anchored to top and bottom, and located as indicated. Include reinforcement of tank at bottom of ladder.
8. Ladders (for vertical tanks): Carbon-steel ladder outside tank, anchored to top and side wall. Comply with requirements in Division 05 Section "Metal Fabrications" for exterior steel ladder.
   a. Cage: Include welded steel cage around ladders for tanks 20 feet (6 m) high or higher.
9. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
10. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).

R. Fuel-Oil UST Accessories
1. Tank Manholes: 22-inch- (560-mm-) minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.
2. Steel Tank Masonry Supports: Two 6-by-6-by-3/8-inch (150-by-150-by-10-mm) steel angles, 72 inches (1800 mm) long, located longitudinally on tank on each side of manholes and continuously welded in place.
3. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gaging, in locations and of sizes indicated. Include cast-iron plugs for shipping.
4. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
5. Lifting Lugs: For handling and installation.
6. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom. Include reinforcement of tank at bottom of ladder.
7. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
8. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches (150 mm) above tank bottom and cut at a 45-degree angle (1:1 slope).
9. Containment Sumps: Fiberglass **OR** PE, **as directed**, with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.

10. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.
11. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables and turnbuckles, of strength at least one and one-half times maximum uplift force of empty tank without backfill in place.
12. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total weight of 3 oz./sq. yd. (101.7 g/sq. m).
13. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at 98 **OR** 99, **as directed**, percent of tank capacity.

S. Fuel-Oil Storage Tank Piping Specialties
1. Fitting Materials: Cast iron, malleable iron, brass, or corrosion-resistant metal; suitable for fuel-oil service.
   a. Surface, Flush-Mounted Fittings: Waterproof and suitable for truck traffic.
   b. Aboveground-Mounted Fittings: Weatherproof.
2. Spill-Containment Fill Boxes: Flush mounting, with drainage feature to drain oil into tank, threaded fill-pipe connection, and wrench operation.
3. Fill Boxes: Flush mounting, with threaded fill-pipe connection and wrench operation.
4. Locking Fill Boxes: Flush mounting, with locking-type inner fill cap for standard padlock and threaded fill-pipe connection.
5. Supply and Sounding Drop Tubes: Fuel-oil supply piping or fitting, inside tank, terminating 6 inches (150 mm) above bottom of tank, and with end cut at a 45-degree angle (1:1 slope).
6. Pipe Adapters and Extensions: Compatible with piping and fittings.
7. Suction Strainers and Check Valves: Bronze or corrosion-resistant metal components.
8. Foot Valves and Antisiphon Valves: Poppet-type, bronze or corrosion-resistant metal components.
9. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.
10. Metal Manholes: 22-inch- (560-mm-) minimum diameter frame and cover. Furnish manhole units of adequate size for access to fittings if size is not indicated.
11. Monitoring Well Caps: Locking pipe plug and manhole.

T. Submersible Fuel-Oil Pumps
1. Description: Comply with UL 79, UL 87, and UL 343.
   a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
   b. Impeller: Turbine.
   c. Housing and Volute: Cast iron.
   d. Bearings: Bronze, self-lubricating.
   e. Seals: Mechanical.
   f. Shaft: Polished steel.
   g. Suspension Piping: Telescoping to accommodate tank diameter and depth of bury.
   h. Base: Steel.
   i. Pressure Relief: Built in.
   j. Discharge Check Valve: Built in.
   k. Drive: Direct, close coupled.
2. Controls: Pump controller panel complying with UL 353 and UL 508C and with interlock and terminals for connections to fuel-oil-burning equipment **OR** diesel-driven fire pumps **OR** diesel-driven emergency generators **OR** diesel-fuel-oil dispenser, **as directed**.
   a. Run pumps to maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).

b. Run pumps on seven-day schedule.
c. Stage pumps on pressure at a common supply manifold.
d. Alternate pumps to equalize run time.
e. Alarm motor failure.
f. Manual reset dry-run protection. Stop pumps if fuel level falls below pump suction.
g. Deenergize and alarm pump locked rotor condition.
h. Alarm open circuit, high and low voltage.
i. Indicating lights for power on, run, and off normal conditions.
j. Interface with automatic control system is specified in Division 15 Section "Hvac Instrumentation And Controls" to control and indicate the following:
1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
2) Operating status.
3) Alarm off-normal status.

3. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Thermal-Overload Protection: Motor-winding temperature sensor.
c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.

U. Simplex Fuel-Oil Transfer Pumps
1. Description: Comply with UL 343, and HI M109.
a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
b. Type: Positive-displacement, rotary type.
c. Impeller: Steel gear with crescent **OR** Carbon vane, **as directed**.
d. Housing: Cast-iron foot mounted.
e. Bearings: Bronze, self-lubricating.
f. Shaft: Polished steel.
g. Seals: Mechanical.
h. Base: Steel.
i. Pressure Relief: Built in.
j. Discharge Check Valve: Built in.
2. Drive: V-belt with guard; gear reducer; or direct, close coupled **OR** V-belt with guard **OR** Gear reducer **OR** Direct, close coupled, **as directed**.
3. Controls:
a. Run pump to maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).
b. Run pump on seven-day schedule.
c. Alarm motor failure.
d. Manual reset dry-run protection. Stop pump if fuel level falls below pump suction.
e. Deenergize and alarm pump locked rotor condition.
f. Alarm open circuit, high and low voltage.
g. Indicating lights for power on, run, and off normal conditions.
h. Interface with automatic control system is specified in Division 15 Section "Hvac Instrumentation And Controls" to control and indicate the following:
1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
2) Operating status.
3) Alarm off-normal status.
4. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.

V. Duplex **OR** Triplex, **as directed**, Fuel-Oil Transfer Pump Sets
1. Description: Comply with HI M109.
   a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
   b. Type: Positive-displacement, rotary type.
   c. Impeller: Steel gear with crescent **OR** Carbon vane, **as directed**.
   d. Housing: Cast-iron foot mounted.
   e. Bearings: Bronze, self-lubricating.
   f. Shaft: Polished steel.
   g. Seals: Mechanical.
   h. Base: Steel.
   i. Pressure Relief: Built in.
   j. Discharge Check Valve: Built in.
2. Drive: V-belt with guard, gear reducer, or direct close coupled **OR** V-belt with guard **OR** Gear reducer **OR** Direct close coupled, **as directed**.
3. Controls:
   a. Run pumps to maintain minimum manifold pressure with outdoor-air temperature less than 60 deg F (16 deg C).
   b. Run pumps on seven-day schedule.
   c. Stage pumps on pressure at a common supply manifold.
   d. Alternate pumps to equalize run time.
   e. Alarm motor failure.
   f. Manual reset dry-run protection. Stop pumps if fuel level falls below pump suction.
   g. Deenergize and alarm pump locked rotor condition.
   h. Alarm open circuit, high and low voltage.
   i. Indicating lights for power on, run, and off normal conditions.
   j. Interface with automatic control system is specified in Division 15 Section "Hvac Instrumentation And Controls" to control and indicate the following:
      1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
      2) Operating status.
      3) Alarm off-normal status.
4. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.
5. Piping Furnished with Pumps: Steel with ferrous fittings and threaded or welded joints.
6. Strainers Furnished with Pumps: Duplex, basket type with corrosion-resistant-metal-screen baskets.

W. Fuel Maintenance System
1. Description: Factory fabricated and wired fuel maintenance system for fuel-oil filtration; with enclosure, filter, fuel-oil pump, and controls; FMG approved, listed, and labeled by an NRTL acceptable to authorities having jurisdiction.
   a. Enclosure: NEMA 250, Type 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.

b. Pump: Comply with HI M109, steel-gear-with-crescent, positive-displacement, direct-coupled, rotary-type.
c. Materials: Cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
d. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   2) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.
e. Piping: Steel with malleable-iron fittings and threaded joints or wrought-steel fittings and welded joints.
f. Multistage Filter: Spin-on, replaceable types.
   1) Stage 1: 100-mesh strainer.
   2) Stage 2: Centrifuge to separate particulates and water from oil.
   3) Stage 3: Coalescing water and particulate filter.
   4) Stage 4: 30-micron particulate removal.
   5) Stage 5: 10-micron particulate removal.
   6) Stage 6: Minimum 99.5 percent water removal with see-through bowl and water-sensor probe.
   7) Stage 7: 1.5 **OR** 3, **as directed**,-micron particulate removal.
g. Multiple-Tank Manifolds:
   1) Manifold fabricated of Schedule 80, black steel pipe and threaded nipples for two **OR** three **OR** four, **as directed**, tanks.
   2) Solenoid valves for supply and return piping to each tank.
   3) Strainers for each tank supply connection.
h. Programmable Logic Controller:
   1) Alarm on maximum 15-in. Hg (51-kPa) vacuum at pump suction indicating plugged filter.
   2) Alarm on high water level in filter.
   3) Alarm leak in enclosure.
   4) Touch screen; with minimum 2-line, 20-character, backlit, LCD display.
   5) Controller strip heater with thermostat.
i. Interface with automatic control system is specified in Division 15 Section "Hvac Instrumentation And Controls" to control and indicate the following:
   1) Start/stop system when required by schedule.
   2) Operating status.
   3) Alarm off-normal status.

X. Liquid-Level Gage System
   1. Description: Calibrated, liquid-level gage system complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.
   2. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
   3. Controls: Electrical, operating on 120-V ac.

Y. Leak-Detection And Monitoring System
   1. Cable and Sensor System: Comply with UL 1238.
      a. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
      b. Include fittings and devices required for testing.
      c. Controls: Electrical, operating on 120-V ac.
      d. Calibrated, liquid-level gage complying with UL 180 with floats **OR** UL 1238 with probes, **as directed,** or other sensors and remote annunciator panel.

e. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
f. Controls: Electrical, operating on 120-V ac.

2. Hydrostatic System: Comply with UL 1238.
   a. Calibrated, leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls.
   b. Include fittings and devices required for testing.
   c. Controls: Electrical, operating on 120-V ac.
   d. Calibrated, liquid-level gage complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.
   e. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
   f. Controls: Electrical, operating on 120-V ac.

Z. Fuel Oil
1. Fuel Oil: ASTM D 396, Grade No. 1 **OR** No. 2, **as directed**.
2. Diesel Fuel Oil: ASTM D 975, Grade Low Sulfur **OR** No. 1-D, special-purpose **OR** No. 2-D, general-purpose, **as directed**, high volatility.

AA. Sleeves
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

BB. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
   b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

CC. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube and with OD that completely covers opening.
2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Escutcheons: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

DD. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

a. Characteristics: Posthardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
c. Packaging: Premixed and factory packaged.

EE. Labeling And Identifying
1. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (152 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (762 mm) deep; colored yellow.

FF. Concrete Manholes
1. Precast Concrete Manhole Sections: ASTM C 478 (ASTM C 478M), base and concentric-cone sections with integral ladder or steps.
2. Cast-Iron Frame and Cover: Heavy-duty, water-resistant, cast-iron manhole frame, gasket, and bolted cover; 24-inch- (609-mm-) diameter, inside opening dimension; 8-inch (203-mm) frame riser height.

GG. Source Quality Control
1. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:
a. Vertical **OR** Horizontal, **as directed**, Single-Wall Steel ASTs: UL 142.
b. Vertical **OR** Horizontal, **as directed**, Double-Wall Steel ASTs: UL 142, STI F921, and STI R931.
c. Horizontal, Containment-Dike, Steel ASTs: UL 142 and STI F911.
d. Horizontal, Concrete-Vaulted **OR** Concrete-Vaulted and Insulated **OR** Insulated, **as directed**, Steel ASTs: UL 142 and UL 2085.
e. Horizontal, Steel USTs with the STI-P3 Corrosion-Protection System: UL 58 and STI P3.
f. Composite **OR** Composite and Jacketed **OR** Jacketed, **as directed**, Steel USTs: UL 58.
g. FRP USTs: UL 1316.
2. Affix standards organization's code stamp.

1.3 EXECUTION

A. Earthwork
1. Comply with requirements in Division 02 Section "Earthwork" for excavating, trenching, and backfilling.

B. Preparation
1. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
2. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

C. Outdoor Piping Installation
1. Install underground fuel-oil piping buried at least 18 inches (457 mm) below finished grade. Comply with requirements in Division 02 Section "Earthwork" for excavating, trenching, and backfilling.
a. If fuel-oil piping is installed with less than 12 inches (305 mm) of cover to finished grade, install in containment piping.
2. Steel Piping with Protective Coating:
a. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage prior to repair.
OR
Replace pipe having damaged PE coating with new pipe.

3. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank sump.
4. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.
5. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.
6. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to AST and UST.
7. Install fittings for changes in direction in rigid pipe.
8. Install system components with pressure rating equal to or greater than system operating pressure.
9. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Install sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
10. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
11. Mechanical Sleeve Seal Installation: Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
12. Install pressure gage on suction **OR** suction and discharge, **as directed**, from each pump. Pressure gages are specified in Division 15 Section "Meters And Gages For Hvac Piping".

D. Indoor Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping free of sags and bends.
7. Install fittings for changes in direction and branch connections.
8. Install escutcheons for penetrations of walls, ceilings, and floors.
   a. New Piping:
      1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
         OR
         Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.
         OR
         Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
      4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
         OR

Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.

5) Piping in Equipment Rooms: One-piece, cast-brass type.
OR
Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.

6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

9. Existing Piping:
   1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   OR
   Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
   2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.
   OR
   Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
   3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.
   OR
   Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
   4) Piping in Equipment Rooms: Split-casting, cast-brass type.
   OR
   Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
   5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
10. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
11. Verify final equipment locations for roughing-in.
12. Comply with requirements for equipment specifications in Division 14 AND Division 15 for roughing-in requirements.
13. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.
14. Prohibited Locations:
    a. Do not install fuel-oil piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    b. Do not install fuel-oil piping in solid walls or partitions.
15. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
16. Connect branch piping from top or side of horizontal piping.
17. Install unions in pipes NPS 2 (DN 50) and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.
18. Do not use fuel-oil piping as grounding electrode.
19. Install Y-pattern **OR** basket **OR** T-pattern, **as directed**, strainer on inlet side of fuel-oil pump.

E. Valve Installation
1. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.
2. Install valves in accessible locations.
3. Protect valves from physical damage.
4. Install metal tag attached with metal chain indicating fuel-oil piping systems.
5. Identify valves as specified in Division 15 Section "Identification For Hvac Piping And Equipment".
6. Install oil safety valves at inlet of each oil-fired appliance.

7. Install pressure relief valves in distribution piping between the supply and return lines.
8. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.
9. Install manual air vents at high points in fuel-oil piping.
10. Install emergency shutoff valves at dispensers (for systems with fuel-oil or diesel-fuel-oil dispensers).

F. Piping Joint Construction
1. Ream ends of pipes and tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.
   a. Bevel plain ends of steel pipe.
   b. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
6. Flanged Joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.
7. Flared Joints: Comply with SAE J513. Tighten finger tight, then use wrench according to fitting manufacturer's written recommendations. Do not overtighten.
8. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

G. Fuel-Oil AST Installation
1. Install tank bases and supports.
2. Connect piping and vent fittings.
3. Install ground connections.
4. Install tank leak-detection and monitoring devices.
5. Install steel ASTs according to STI R912.
6. Install insulated and concrete-vaulted, steel ASTs according to STI R942.
7. Fill storage tanks with fuel oil.

H. Fuel-Oil UST Installation
1. Excavate to sufficient depth for a minimum of 3 feet (1 m) of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus 6 inches (150 mm) of sand or pea gravel between ballast base and tank. Extend excavation at least 12 inches (300 mm) around perimeter of tank.
2. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.
3. Place 6 inches (152 mm) of clean sand or pea gravel on top of concrete-ballast base.
4. Set tank on fill materials and install hold-down straps.
5. Connect piping.
6. Install tank leak-detection and monitoring devices.
7. Install containment sumps.
8. Backfill excavation with clean sand or pea gravel in 12-inch (305-mm) lifts and tamp backfill lift to consolidate.
9. Install filter mat between top of backfill material and earth fill.
10. Install steel USTs with the STI-P3 corrosion-protection system according to STI R821 and STI R891. Protect anodes during tank placement and backfilling operations.

11. Install composite, steel USTs according to STI R913 and STI R891.
12. Install jacketed, steel USTs according to STI R923 and STI R891.
13. Install FRP USTs with FRP hold-down straps, manhole extensions, and manhole risers.
14. Fill storage tanks with fuel oil.

I. Hanger And Support Installation
1. Pipe hanger and support and equipment support materials and installation requirements are specified in Division 15 Section "Hangers And Supports For Hvac Piping And Equipment".
2. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   a. NPS 1-1/4 (DN 32) and Smaller: Maximum span, 84 inches (2130 mm); minimum rod size, 3/8 inch (10 mm).
   b. NPS 1-1/2 (DN 40): Maximum span, 108 inches (2740 mm); minimum rod size, 3/8 inch (10 mm).
   c. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
   d. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 1/2 inch (13 mm).
   e. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).
   f. NPS 4 (DN 100): Maximum span, 13 feet (4 m); minimum rod size, 5/8 inch (16 mm).
3. Support vertical steel pipe at each floor and at spacing not greater than 15 feet (4.5 m).
4. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
   a. NPS 3/4 (DN 20) and Smaller: Maximum span, 60 inches (1524 mm); minimum rod size, 3/8 inch (10 mm).
   b. NPS 1 (DN 25): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
   c. NPS 1-1/4 (DN 32): Maximum span, 84 inches (2130 mm); minimum rod size, 3/8 inch (10 mm).
   d. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
   e. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2740 mm); minimum rod size, 1/2 inch (13 mm).
   f. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
   g. NPS 4 (DN 100): Maximum span, 11 feet (3.4 m); minimum rod size, 5/8 inch (16 mm).
5. Support vertical copper tube at each floor and at spacing not greater than 10 feet (3 m).

J. Fuel-Oil Pump Installation
1. Submersible Pumps:
   a. Suspend pumps from supply piping and anchored to bottom of tank.
2. Transfer Pumps:
   a. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
   b. Set pumps on and anchor to concrete base.
3. Install two-piece, full-port ball valves at suction and discharge of pumps.
4. Install mechanical leak-detector valves at pump discharge.
5. Install Y-pattern **OR** basket **OR** T-pattern, **as directed**, strainer on inlet side of simplex fuel-oil pumps.
6. Install check valve on discharge of simplex fuel-oil pumps.
7. Install suction piping with minimum fittings and change of direction.
8. Install vacuum and pressure gage, upstream and downstream respectively, at each pump to measure the differential pressure across the pump. Pressure gages are specified in Division 15 Section "Meters And Gages For Hvac Piping".

K. Fuel Maintenance System Installation
1. Install suction line, with foot valve, at one end of storage tank, 1 inch (25 mm) from the bottom of tank.
2. Install return line at the opposite end of storage tank from suction line.

L. Liquid-Level Gage System Installation
1. Install liquid-level gage system. Locate panel inside building where indicated.

M. Leak-Detection And Monitoring System Installation
1. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.
   a. Double-Wall, Fuel-Oil Storage Tanks: Install probes **OR** Install probes or use factory-installed integral probes **OR** Use factory-installed integral probes, **as directed**, in interstitial space.
   b. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated.
   c. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping **OR** cable probes in interstitial space of double-containment piping, **as directed**.
   d. Install liquid-level gage.

N. Connections
1. Install piping adjacent to equipment to allow service and maintenance.
2. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.
3. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
4. Connect piping to equipment with ball valve and union. Install union between valve and equipment.
5. Install flexible piping connectors at final connection to burners or oil-fired appliances that must be moved for maintenance access.

O. Labeling And Identifying
1. Nameplates, pipe identification, and signs are specified in Division 15 Section "Identification For Hvac Piping And Equipment".
   OR
   Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.
   a. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
2. Install detectable warning tape directly above fuel-oil piping, 12 inches (304 mm) below finished grade, except 6 inches (152 mm) below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.
   a. Piping: Over underground fuel-oil distribution piping.
   b. Fuel-Oil Storage Tanks: Over edges of each UST.

P. Field Painting Of AST
1. If shop painting AST, prepare and touch up damaged exterior surface of AST and supports, **as directed**, as specified in "Shop Painting of AST" Article.
2. If field painting AST, prepare exterior steel surface of AST and tank supports, **as directed**.
3. Field Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 **OR** SSPC-SP 10/NACE No. 2, **as directed**.
4. After cleaning, remove dust or residue from cleaned surfaces.
5. If surfaces develop rust before prime coat is applied, repeat surface preparation.
6. Prepare surface of AST and supports, **as directed**, and apply painting systems according to specifications in Division 09 Section "High-performance Coatings" for severe **OR** moderate **OR** mild, **as directed**, environment high-gloss **OR** semigloss, **as directed**, finish for ferrous metal.

Q. Field Painting Of Aboveground Piping
1. Comply with requirements in Division 07 for painting interior and exterior fuel-oil piping.

2. Paint exposed, exterior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
   a. Alkyd System: MPI EXT 5.1D.
      1) Prime Coat: Alkyd anticorrosive metal primer.
      2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
      3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
      4) Color: Gray, **as directed**.
3. Paint exposed, interior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
   a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
      2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
      3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
      4) Color: Gray, **as directed**.
   b. Alkyd System: MPI INT 5.1E.
      1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
      2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
      3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
      4) Color: Gray, **as directed**.
4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

R. Concrete Bases
1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (457-mm) centers around the full perimeter of the base.
   c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
   f. Use 3000-psig (20.7-MPa), **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".

S. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:
      1) Single-Wall Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
      2) Double-Wall Tanks:
         a) Inner Tanks: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa).
         b) Interstitial Space: Minimum 3 psig (20.7 kPa) and maximum 5 psig (34.5 kPa), or 5.3-in. Hg (18-kPa) vacuum.

3) Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than 10 psig (69 kPa), hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
4) Maintain the test pressure for one hour.

b. Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:
1) Fuel-Oil Distribution Piping: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
2) Fuel-Oil, Double-Containment Piping:
a) Carrier Pipe: Minimum 5 psig (34.5 kPa) for minimum 30 minutes.
b) Containment Conduit: Minimum 5 psig (34.5 kPa) for minimum 60 minutes.
3) Suction Piping: Minimum 20-in. Hg (68 kPa) for minimum 30 minutes.
4) Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig (69 kPa).

c. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.

d. Test liquid-level gage for accuracy by manually measuring fuel-oil levels at not less than three **OR** four **OR** five, **as directed**, different depths while filling tank and checking against gage indication.

e. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.

f. Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks.

g. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

h. Bleed air from fuel-oil piping using manual air vents.

3. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.

4. Prepare test and inspection reports.

T. Outdoor Piping Schedule

1. Underground fuel-oil piping shall be one of the following. Size indicated is carrier-pipe size.
a. Flexible, double-containment piping.
b. Rigid, double-containment piping.

2. Underground fuel-oil-tank fill and vent piping shall be one of the following:
a. NPS 2 (DN 50) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.
b. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel welding fittings, and welded joints. Coat pipe and fittings with protective coating for steel piping.

3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

4. Aboveground fuel-oil piping shall be one of the following:
a. NPS 2 (DN 50) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.
b. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel welding fittings, and welded joints.
c. Annealed **OR** Drawn, **as directed**,-temper copper tube with wrought-copper fittings and brazed joints.

U. Indoor Piping Schedule

1. Aboveground fuel-oil piping shall be one of the following:
a. NPS 1/2 (DN 15) and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints **OR** Annealed-temper copper pipe, wrought copper fittings, and brazed or flared joints, **as directed**.
b. NPS 5/8 to NPS 2 (DN 18 to DN 50): Steel pipe, steel or malleable-iron threaded fittings, and threaded joints **OR** Drawn temper copper pipe, wrought copper fittings, and brazed joints, **as directed**.

c. NPS 2-1/2 (DN 65) and Larger: Steel pipe, steel fittings, and welded or flanged joints **OR** Drawn temper copper pipe, wrought copper fittings, and brazed or flanged joints, **as directed**.
d. Steel pipe with malleable-iron fittings and threaded joints.
e. Steel pipe with wrought-steel fittings and welded joints.
f. Annealed-temper copper tube, brass fittings, and flared joints.
g. Drawn-temper copper tubing, copper fittings, and brazed joints.

V. Aboveground Manual Fuel-Oil Shutoff Valve Schedule
1. Distribution piping valves for pipe NPS 2 (DN 50) and smaller shall be one of the following:
   a. One-piece, bronze ball valve with bronze trim.
   b. Two-piece, full **OR** regular, **as directed**,-port, bronze ball valves with bronze trim.
2. Distribution piping valves for pipe NPS 2-1/2 (DN 65) and larger shall be one of the following:
   a. Two-piece, full **OR** regular, **as directed**,-port, bronze ball valves with bronze trim.
   b. Bronze, nonlubricated **OR** lubricated, **as directed**, plug valve.
3. Valves in branch piping for single appliance shall be one of the following:
   a. One-piece, bronze ball valve with bronze trim.
   b. Two-piece, full **OR** regular, **as directed**,-port, bronze ball valves with bronze trim.

END OF SECTION 15061i

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SECTION 15061j - GENERAL-SERVICE COMPRESSED-AIR PIPING

1.1 GENERAL

A. Description Of Work:
1. This specification covers the furnishing and installation of materials for general-service compressed-air piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes piping and related specialties for general-service compressed-air systems operating at 200 psig (1380 kPa) or less.

C. Definitions
1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CR: Chlorosulfonated polyethylene synthetic rubber.
3. EPDM: Ethylene-propylene-diene terpolymer rubber.
4. HDPE: High-density polyethylene plastic.
5. NBR: Acrylonitrile-butadiene rubber.
6. PE: Polyethylene plastic.
7. PVC: Polyvinyl chloride plastic.
8. High-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures between 150 and 200 psig (1035 and 1380 kPa).
9. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig (1035 kPa) or less.

D. Performance Requirements
1. Seismic Performance: Compressed-air piping and support and installation shall withstand effects of seismic events determined according to SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures.".

E. Submittals
1. Product Data: For the following:
   a. Plastic pipes, fittings, and valves.
   b. Dielectric fittings.
   c. Flexible pipe connectors.
   d. Safety valves.
   e. Pressure regulators. Include rated capacities and operating characteristics.
   f. Automatic drain valves.
   g. Filters. Include rated capacities and operating characteristics.
   h. Lubricators. Include rated capacities and operating characteristics.
   i. Quick couplings.
   j. Hose assemblies.
2. Brazing **OR** Welding, **as directed**, certificates.
3. Field quality-control test reports.
4. Operation and maintenance data.

F. Quality Assurance
1. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
2. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

3. ASME Compliance:
   a. Comply with ASME B31.1, "Power Piping," for high-pressure compressed-air piping.
   b. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

G. Project Conditions
1. Interruption of Existing Compressed-Air Service: Do not interrupt compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary compressed-air service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of compressed-air service.
   b. Do not proceed with interruption of compressed-air service without Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings
1. Schedule 40, Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1.
   a. Steel Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized seamless steel pipe. Include ends matching joining method.
   b. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.
   c. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.
   d. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded.
   e. Wrought-Steel Butt-Welding Fittings: ASME B16.9, Schedule 40.
   f. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel.
   g. Grooved-End Fittings and Couplings:
      1) Grooved-End Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron casting; with grooves according to AWWA C606 and dimensions matching steel pipe.
      2) Couplings: AWWA C606 or UL 213, for steel-pipe dimensions and rated for 300-psig (2070-kPa) minimum working pressure. Include ferrous housing sections, gasket suitable for compressed air, and bolts and nuts. Provide EDPM gaskets for oil-free compressed air. Provide NBR gaskets if compressed air contains oil or oil vapor.
2. Schedule 5, Steel Pipe: ASTM A 135, carbon steel with plain ends and zinc-plated finish.
   a. Pressure-Seal Fittings: Listed and labeled by a qualified testing agency and FMG-approved, carbon-steel, pressure-seal housing with O-ring end seals suitable for compressed-air piping and rated for 300-psig (2070-kPa) minimum working pressure. Provide EDPM seals for oil-free compressed air. Provide NBR seals if compressed air contains oil or oil vapor.
3. Copper Tube: ASTM B 88, Type K or L (ASTM B 88M, Type A or B) and ASTM B 88, Type M (ASTM B 88M, Type C) seamless, drawn-temper, water tube.
   a. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
   b. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
   c. Copper Unions: ASME B16.22 or MSS SP-123.
   d. Press-Type Fittings, NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
   e. Press-Type Fittings, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
   f. Extruded-Tee Outlets: Procedure for making branch outlets in copper tube according to ASTM F 2014.

g. Grooved-End Fittings and Couplings:
   1) Grooved-End Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze castings.
   2) Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for compressed air, and bolts and nuts. Provide EDPM gasket for oil-free compressed air. Provide NBR gasket if compressed air contains oil or oil vapor.

4. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
5. PVC Pipe: ASTM D 1785, Schedule 40.
   a. PVC Fittings: ASTM D 2466, Schedule 40, socket type.
6. Blue ABS Piping System: Made of ASTM D 3965, ABS-resin modified to provide shatter-resistant pipe for compressed-air service. Pipe and fittings are light blue and sizes are in millimeters.
   a. Transition Fittings, 20 to 63 mm: Composite union with ABS socket end, CR O-ring, and malleable-iron union nut and threaded end; with construction similar to MSS SP-107, transition union.
   b. Transition Fittings, 90 to 110 mm: Flange assembly with ABS flange, CR gasket, and metal flange of material matching piping to be connected.
   c. Valves, 20 to 63 mm: ABS union ball valve with socket ends.
   d. Valves, 90 to 110 mm: ABS butterfly valve with lever handle.
7. Green ABS Piping System: Made of ASTM D 3965, ABS-resin modified to provide shatter-resistant pipe for compressed-air service. Pipe and fittings are dark green with SDR of 9.0 and same OD as ASTM A 53/A 53M, steel pipe.
   a. Transition Fittings, NPS 1/2 to NPS 2 (DN 15 to DN 50): Composite union with ABS socket end, CR O-ring, ABS union nut, and brass solder-joint end; with construction similar to MSS SP-107, transition union.
   b. Transition Fittings, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): ABS flange, CR gasket, and metal flange of material matching piping to be connected.
   c. Valves, NPS 1/2 to NPS 2 (DN 15 to DN 50): Union ball valve with socket ends.
   d. Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Union ball valve with flanged ends. Include safety exhaust feature in Part 3 "Valve Applications" Article if required.
8. HDPE Piping System: Made of ASTM D 1248, HDPE resin to provide shatter-resistant pipe for compressed-air service. Pipe and fittings are dark blue with pipe dimensions about the same OD as ASTM D 3035, PE pipe.
   a. Transition Fittings, NPS 1/2 to NPS 2 (DN 15 to DN 50): HDPE adapter with one socket end and one end with threaded brass insert.
   b. Transition Fittings, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): HDPE flange, CR gasket, and metal flange of material matching piping to be connected.
   c. Valves, NPS 1/2 to NPS 3 (DN 15 to DN 80): HDPE union ball valve with socket ends.

B. Joining Materials
1. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.
   a. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
      1) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
      2) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
3. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
5. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.
6. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
7. Solvent Cements for Joining Plastic Piping:

a. ABS Piping: ASTM D 2235.
b. PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.

C. Valves
1. Metal Ball, Butterfly, Check, Gate, and Globe Valves: Comply with requirements in Division 15 Section "General-duty Valves For Plumbing Piping".

D. Dielectric Fittings
1. General Requirements for Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with insulating material; suitable for system fluid, pressure, and temperature. Include threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
2. Dielectric Unions: Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
3. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
4. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   a. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

E. Flexible Pipe Connectors
1. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
   b. End Connections, NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
   c. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
2. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
   a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
   b. End Connections, NPS 2 (DN 50) and Smaller: Threaded steel pipe nipple.
   c. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

F. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

G. Escutcheons
1. General Requirements: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Escutcheons: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.

6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Escutcheons: Cast iron.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

H. Specialties
1. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
   a. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.
2. Air-Main Pressure Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig (1725-kPa) inlet pressure, unless otherwise indicated.
   a. Type: Pilot operated.
3. Air-Line Pressure Regulators: Diaphragm **OR** Pilot, **as directed**, operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.
   OR
   Air-Line Pressure Regulators: Diaphragm operated, aluminum alloy or plastic body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.
4. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is indicated, **as directed**.
5. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated, **as directed**.
6. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration, and drain cock. Include mounting bracket if wall mounting is indicated, **as directed**.
7. Air-Line Lubricators: With drip chamber and sight dome for observing oil drop entering air stream; with oil-feed adjustment screw and quick-release collar for easy bowl removal. Include mounting bracket if wall mounting is indicated, **as directed**.
   a. Provide with automatic feed device for supplying oil to lubricator.

I. Quick Couplings
1. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.
2. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
   a. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
   b. Plug End: Flow-sensor-bleeder, check-valve **OR** Straight-through, **as directed**, type with barbed outlet for attaching hose.
3. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.
   a. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
   b. Plug End: With barbed outlet for attaching hose.

J. Hose Assemblies
1. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig (2070-kPa) minimum working pressure, unless otherwise indicated.

a. Hose: Reinforced single **OR** double, **as directed**,-wire-braid, CR-covered hose for compressed-air service.
b. Hose Clamps: Stainless-steel clamps or bands.
c. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
d. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

K. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Piping Applications
1. Compressed-Air Piping between Air Compressors and Receivers: Use one of the following piping materials for each size range:
a. NPS 2 (DN 50) and Smaller: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
b. NPS 2 (DN 50) and Smaller: Schedule 5, galvanized-steel pipe; pressure-seal fittings; and pressure-sealed joints.
c. NPS 2 (DN 50) and Smaller: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
d. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
e. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
f. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
g. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
h. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
i. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
j. NPS 5 (DN 125) and Larger: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
k. NPS 5 (DN 125) and Larger: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
l. NPS 5 (DN 125) and Larger: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
m. NPS 5 (DN 125) and Larger: Grooved-end, Type K or L (ASTM B 88M Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
2. Low-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:
a. NPS 2 (DN 50) and Smaller: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
b. NPS 2 (DN 50) and Smaller: Schedule 5, galvanized-steel pipe; pressure-seal fittings; and pressure-sealed joints.
c. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.

d. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; press-type fittings; and pressure-sealed joints.
e. NPS 2 (DN 50) and Smaller: 63-mm and smaller, blue ABS pipe and fittings; transition fittings; valves; and solvent-cemented joints.
f. NPS 2 (DN 50) and Smaller: Green ABS pipe and fittings, transition fittings, and valves; and solvent-cemented joints.
g. NPS 2 (DN 50) and Smaller: HDPE pipe, fittings, and valves; and heat-fusion joints.
h. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
i. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
j. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
k. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
l. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; press-type fittings; and pressure-sealed joints.
m. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 90- and 110-mm, blue ABS pipe and fittings; transition fittings; and solvent-cemented joints. Include butterfly valves and flanged joints.
n. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): NPS 3 and NPS 4 (DN 80 and DN 100), green ABS pipe and fittings; transition fittings; and solvent-cemented joints. Include ball valves and flanged joints.
o. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): NPS 3 and NPS 4 (DN 80 and DN 100), HDPE pipe and fittings; valves; and heat-fusion joints.
p. NPS 5 and NPS 6 (DN 125 and DN 150): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
q. NPS 5 (DN 125) and Larger: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
r. NPS 5 to NPS 8 (DN 125 to DN 200): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.

3. High-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:
   a. NPS 2 (DN 50) and Smaller: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
   b. NPS 2 (DN 50) and Smaller: Schedule 5, galvanized-steel pipe; pressure-seal fittings; and pressure-sealed joints.
   c. NPS 2 (DN 50) and Smaller: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
   d. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
   e. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; threaded, malleable-iron fittings; and threaded joints.
   f. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
   g. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.
   h. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
   i. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
   j. NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.
   k. NPS 8 (DN 200) and Larger: Schedule 40, black **OR** galvanized, **as directed**,-steel pipe; grooved-end fittings; couplings; and grooved joints.
   l. NPS 8 (DN 200) and Larger: Schedule 40, black-steel pipe; wrought-steel fittings; and welded joints.

m. NPS 8 (DN 200): Type K or L (Type A or B), copper tube; grooved-end copper fittings; couplings; and grooved joints.

4. Drain Piping: Use one of the following piping materials:
   a. NPS 2 (DN 50) and Smaller: Type M (Type C) copper tube; wrought-copper fittings; and brazed or soldered joints.
   b. NPS 2 (DN 50) and Smaller: PVC pipe and fittings; and solvent-cemented joints.

B. Valve Applications
1. General-Duty Valves: Comply with requirements in Division 15 Section "General-duty Valves For Plumbing Piping" for metal general-duty valves. Use metal valves, unless otherwise indicated.
   a. Metal General-Duty Valves: Use valve types specified in "Valve Applications" Article in Division 15 Section "General-duty Valves For Plumbing Piping" according to the following:
      1) Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.
      2) High-Pressure Compressed Air: Valve types specified for medium-pressure compressed air.
      3) Equipment Isolation NPS 2 (DN 50) and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.
      4) Grooved-end valves may be used with grooved-end piping and grooved joints.
   b. Plastic General-Duty Valves: Provide valves, made by piping manufacturer, that are compatible with piping. Do not use plastic valves between air compressors and receivers.
      1) Blue ABS Piping System: Ball and butterfly valves.
      2) Green ABS Piping System: Ball valves.
      3) HDPE Piping System: Ball valves.

C. Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.
3. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.
4. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.
5. Install piping adjacent to equipment and machines to allow service and maintenance.
6. Install air and drain piping with 1 percent slope downward in direction of flow.
7. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.
8. Equipment and Specialty Flanged Connections:
   a. Use steel companion flange with gasket for connection to steel pipe.
   b. Use cast-copper-alloy companion flange with gasket and brazed **OR** soldered, **as directed**, joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.
9. Flanged joints may be used instead of specified joint for any piping or tubing system.
10. Extended-tee outlets with brazed branch connection may be used for copper tubing, within extruded-tee connection diameter to run tube diameter ratio for tube type, according to Extruded Tee Connections Sizes and Wall Thickness for Copper Tube (Inches) Table in ASTM F 2014.
11. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
12. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.

13. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 15 Section "Meters And Gages For Plumbing Piping".
14. Install piping to permit valve servicing.
15. Install piping free of sags and bends.
16. Install fittings for changes in direction and branch connections.
17. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".

D. Joint Construction
1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.
5. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
6. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B 828 or CDA's "Copper Tube Handbook."
7. Extruded-Tee Outlets for Copper Tubing: Form branches according to ASTM F 2014, with tools recommended by procedure manufacturer, and using operators qualified according to Part 1 "Quality Assurance" Article.
8. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
9. Grooved Joints: Assemble couplings with housing, gasket, lubricant, and bolts. Join according to AWWA C606 for grooved joints. Do not apply lubricant to prelubricated gaskets.
10. Heat-Fusion Joints for PE Piping: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657 for socket-fusion joints.
11. Pressure-Sealed Joints: Join with tools recommended by fitting manufacturer, using operators qualified according to Part 1 "Quality Assurance" Article.
12. Solvent-Cemented Joints for ABS Piping: Clean and dry joining surfaces. Join according to the following:
    a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
    b. Join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2235 Appendix.
13. Solvent-Cemented Joints for PVC Piping: Clean and dry joining surfaces. Join according to the following:
    a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
    b. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2672.
14. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

E. Valve Installation
1. General-Duty Valves: Comply with requirements in Division 15 Section "General-duty Valves For Plumbing Piping".
2. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.
3. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.
4. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

F. Dielectric Fitting Installation
1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. NPS 2 (DN 50) and Smaller: Use dielectric unions.
3. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
4. NPS 5 (DN 125)and Larger: Use dielectric flange kits.

G. Flexible Pipe Connector Installation
1. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter, **as directed**, of each air compressor.
2. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.
3. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

H. Specialty Installation
1. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.
2. Install air-main pressure regulators in compressed-air piping at or near air compressors.
3. Install air-line pressure regulators in branch piping to equipment and tools, **as directed**.
4. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.
5. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters. Mount on wall at locations indicated, **as directed**.
6. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters. Mount on wall at locations indicated, **as directed**.
7. Install air-line lubricators in branch piping to machine tools. Mount on wall at locations indicated, **as directed**.
8. Install quick couplings at piping terminals for hose connections.
9. Install hose assemblies at hose connections.

I. Connections
1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment and machine.

J. Sleeve Installation
1. Sleeves are not required for core-drilled holes.
2. Permanent sleeves are not required for holes formed by removable PE sleeves.
3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
   OR
   Install sleeves for pipes passing through concrete and masonry walls, gypsum board partitions, and concrete floor and roof slabs.
   a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
   b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
4. Install sleeves in new walls and slabs as new walls and slabs are constructed.
5. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to

2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

6. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

K. Escutcheon Installation

1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   a. New Piping:
      1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
      2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
      3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split-casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.
      4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
      5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
      6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
   b. Existing Piping:
      1) Chrome-Plated Piping: Split-casting, cast brass with chrome-plated finish.
      2) Insulated Piping: Split-plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
      3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
      4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
      5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
      6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
      7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

L. Hanger And Support Installation

1. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
2. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
3. Vertical Piping: MSS Type 8 or 42, clamps.
4. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet (30 m) or Less: MSS Type 1, adjustable, steel clevis hangers.

b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.

5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.
7. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
8. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
9. Install hangers for Schedule 40, steel piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1/4 to NPS 1/2 (DN 8 to DN 15): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3/4 to NPS 1-1/4 (DN 20 to DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   c. NPS 1-1/2 (DN 40): 12 feet (3.7 m) with 3/8-inch (10-mm) rod.
   d. NPS 2 (DN 50): 13 feet (4 m) with 3/8-inch (10-mm) rod.
   e. NPS 2-1/2 (DN 65): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
   f. NPS 3 (DN 80): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
   g. NPS 3-1/2 (DN 90): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
   h. NPS 4 (DN 100): 17 feet (5.2 m) with 5/8-inch (16-mm) rod.
   i. NPS 5 (DN 125): 19 feet (5.8 m) with 5/8-inch (16-mm) rod.
   j. NPS 6 (DN 150): 21 feet (6.4 m) with 3/4-inch (19-mm) rod.
   k. NPS 8 (DN 200): 24 feet (7.3 m) with 3/4-inch (19-mm) rod.
   l. NPS 10 (DN 250): 26 feet (7.9 m) with 7/8-inch (22-mm) rod.
   m. NPS 12 (DN 300): 30 feet (9.1 m) with 7/8-inch (22-mm) rod.
10. Install supports for vertical, Schedule 40, steel piping every 15 feet (4.6 m).
11. Install hangers for Schedule 5, steel piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1/2 (DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   c. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   d. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   e. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   f. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
12. Install supports for vertical, Schedule 5, steel piping every 10 feet (3 m).
13. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
   h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
   i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
   j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
   k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
   l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
   m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
   n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.
14. Install supports for vertical copper tubing every 10 feet (3 m).
15. Install vinyl-coated hangers for ABS piping with the following maximum horizontal spacing and minimum rod diameters:
   a. All Sizes: Install continuous support for piping with compressed air at normal operating temperature above 100 deg F (38 deg C).
   b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 30 inches (760 mm) with 3/8-inch (10-mm) rod.

c. NPS 3/4 (DN 20): 38 inches (975 mm) with 3/8-inch (10-mm) rod.
d. NPS 1 (DN 25): 40 inches (1015 mm) with 3/8-inch (10-mm) rod.
e. NPS 1-1/4 (DN 32): 45 inches (1140 mm) with 3/8-inch (10-mm) rod.
f. NPS 1-1/2 (DN 40): 52 inches (1330 mm) with 3/8-inch (10-mm) rod.
g. NPS 2 (DN 50): 58 inches (1470 mm) with 3/8-inch (10-mm) rod.
h. NPS 3 (DN 80): 68 inches (1730 mm) with 1/2-inch (13-mm) rod.
i. NPS 4 (DN 100): 76 inches (1900 mm) with 1/2-inch (13-mm) rod.

16. Install supports for vertical ABS piping every 48 inches (1220 mm).
17. Install vinyl-coated hangers for HDPE piping with the following maximum horizontal spacing and minimum rod diameters:
    a. All Sizes: Install continuous support for piping with compressed air at normal operating temperature above 100 deg F (38 deg C).
    b. NPS 1/2 (DN 15): 30 inches (760 mm) with 3/8-inch (10-mm) rod.
    c. NPS 3/4 (DN 20): 35 inches (890 mm) with 3/8-inch (10-mm) rod.
    d. NPS 1 (DN 25): 40 inches (1015 mm) with 3/8-inch (10-mm) rod.
    e. NPS 1-1/4 (DN 32): 43 inches (1090 mm) with 3/8-inch (10-mm) rod.
    f. NPS 1-1/2 (DN 40): 49 inches (1245 mm) with 3/8-inch (10-mm) rod.
    g. NPS 2 (DN 50): 55 inches (1400 mm) with 3/8-inch (10-mm) rod.
    h. NPS 3 and NPS 4 (DN 80 and DN 100): 96 inches (2440 mm) with 1/2-inch (13-mm) rod.
18. Install supports for vertical HDPE piping every 48 inches (1220 mm).

M. Labeling And Identification
1. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Division 15 Section "Identification For Plumbing Piping And Equipment".

N. Field Quality Control
1. Perform field tests and inspections.
2. Tests and Inspections:
    a. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
    b. Piping Leak Tests for ABS Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen, at temperature of 110 deg F (43 deg C) or less, to pressure of 40 psig (275 kPa) above system operating pressure, but not less than 80 psig (550 kPa) **OR** 100 psig (690 kPa), **as directed**, or more than 120 psig (825 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
    c. Piping Leak Tests for HDPE Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen, at temperature of 100 deg F (38 deg C) or less, to pressure of 40 psig (275 kPa) above system operating pressure, but not less than 100 psig (690 kPa) **OR** 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, or more than 180 psig (1240 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
    d. Repair leaks and retest until no leaks exist.
    e. Inspect filters, lubricators, and pressure regulators for proper operation.
3. Prepare test reports.

END OF SECTION 15061j

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Task	Specification	Specification Description
15061	02456b	Steam Distribution
15061	02551	Facility Natural-Gas Piping
15061	02551a	Facility Liquefied-Petroleum Gas Piping
15062	02455b	Sanitary Sewerage
15062	15061	Common Work Results for Fire Suppression
15062	15061a	Common Work Results for Plumbing
15062	15061b	Common Work Results for HVAC
15062	15061d	Sanitary Waste And Vent Piping
15062	15061e	Storm Drainage Piping
15062	15061j	General-Service Compressed-Air Piping

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SECTION 15063 - COMPRESSED-AIR PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for compressed-air piping for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "laboratory air," operating at 50 psig (345 kPa) **OR** 100 psig (690 kPa) **OR** 125 psig (860 kPa), **as directed**.
b. Medical air piping and specialties, designated "medical air," operating at 50 to 55 psig (345 to 380 kPa).
c. Dental air piping and specialties, designated "dental air," operating at 80 to 100 psig (550 to 690 kPa).
d. Gas-powered-tool air piping and specialties, designated "instrument air," operating at 175 psig (1200 kPa).
e. Healthcare laboratory air piping and specialties, designated "medical laboratory air," operating at 100 psig (690 kPa).

C. Definitions
1. D.I.S.S.: Diameter-index safety system.
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
3. Medical Compressed-Air Piping Systems: Include medical air, dental air, instrument air, and medical laboratory air piping systems.

D. Submittals
1. Product Data: For the following:
a. Compressed-air tubes and fittings.
b. Compressed-air valves and valve boxes.
c. Medical compressed-air service connections.
d. Medical compressed-air pressure control panels.
e. Medical compressed-air manifolds.
f. Medical compressed-air alarm system components.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Piping Material Certification: Signed by Installer certifying that medical compressed-air piping materials comply with NFPA 99 requirements.
4. Brazing certificates.
5. Field quality-control test reports.
6. Operation and maintenance data.

E. Quality Assurance
1. Installer Qualifications:
a. Medical Compressed-Air Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.
b. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.

2. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization **OR** is an NRTL, **as directed**, and that is acceptable to authorities having jurisdiction.
   a. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
3. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 15 Section "Gas Piping For Laboratory And Healthcare Facilities".
4. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
6. ASME Compliance:
   a. Comply with ASME B31.1, "Power Piping," for laboratory compressed-air piping operating at more than 150 psig (1035 kPa).
   b. Comply with ASME B31.9, "Building Services Piping," for laboratory compressed-air piping operating at 150 psig (1035 kPa) or less.
7. Comply with NFPA 99, "Health Care Facilities," for medical compressed-air system materials and installation in healthcare facilities.

F. Project Conditions
1. Interruption of Existing Laboratory and Medical Compressed-Air Service(s): Do not interrupt laboratory or medical compressed-air service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of laboratory and medical compressed-air service(s).
   b. Do not proceed with interruption of laboratory and medical compressed-air service(s) without Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings
1. Copper Medical Gas Tube: ASTM B 819, Type K **OR** Type L, **as directed**, seamless, drawn temper, that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.
   a. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   c. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
   d. Press-Type Fittings:
      1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
      2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
2. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.

3. Copper Water Tube: ASTM B 88, Type M (ASTM B 88M, Type C), seamless, drawn temper.
   a. Copper Fittings: ASME B16.18, cast-copper or ASME B16.22, wrought-copper, solder-joint pressure type.
   b. Press-Type Fittings:
      1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
      2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
4. PVC Pipe: ASTM D 1785, Schedule 40.
   a. PVC Fittings: ASTM D 2466, Schedule 40, socket type.

B. Joining Materials
1. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
2. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
3. Threaded-Joint Tape: PTFE.
4. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.

C. Valves
1. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
2. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Ball: Full-port, chrome-plated brass.
   c. Seats: PTFE or TFE.
   d. Handle: Lever type with locking device, **as directed**.
   e. Stem: Blowout proof with PTFE or TFE seal.
   f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
3. Check Valves: In-line pattern, bronze.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Operation: Spring loaded.
   c. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
4. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Ball: Full-port, chrome-plated brass.
   c. Seats: PTFE or TFE.
   d. Handle: Lever type with locking device, **as directed**.
   e. Stem: Blowout proof with PTFE or TFE seal.
   f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
   g. Pressure Gage: Manufacturer installed on one copper-tube extension.
5. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
   a. Interior Finish: Factory-applied white enamel.
   b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Satin-chrome finish steel **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
   c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

   OR

   Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.

a. Interior Finish: Factory-applied white enamel.
b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

6. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.
7. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated relieving type; manual pressure-setting adjustment; rated for 250-psig (1725-kPa) minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.
8. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated, **as directed**.

D. Medical Compressed-Air Service Connections

1. Connection Devices: For specific medical compressed-air pressure and service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
   a. Roughing-in Assembly:
      1) Steel outlet box for recessed mounting and concealed piping.
      2) Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed.
      3) Double seals that will prevent air leakage.
      4) ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.
   b. Finishing Assembly:
      1) Brass housing with primary check valve.
      2) Double seals that will prevent air leakage.
      3) Cover plate with gas-service label.
   c. Quick-Coupler Service Connections: Pressure outlet with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.
   d. D.I.S.S. Service Connections: Pressure outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.
      1) Medical Air Service Connections: CGA V-5, D.I.S.S. No. 1160.
      2) Instrument Air Service Connections: CGA V-5, D.I.S.S. No. 1160.
   e. Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent, color-coded, identifying label matching corresponding service.

E. Medical Compressed-Air Pressure Control Panels

1. Description: Steel box and support brackets for recessed roughing in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.
   a. Minimum Working Pressure: 200 psig (1380 kPa).
   b. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.
   c. Pressure Gages: 0- to 300-psig (0- to 2070-kPa) range.

d. Service Connection: CGA V-5, D.I.S.S. No. 1160, instrument air outlet.
e. Before final assembly, provide temporary dust shield and U-tube for testing.
f. Label cover plate "Air Pressure Control."

F. Medical Compressed-Air Manifolds
1. General Requirements for Medical Compressed-Air Manifolds: Comply with NFPA 99, Ch. 5, "Manifolds for Gas Cylinders without Reserve Supply."
2. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.
3. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
4. Compressed-Air Cylinders: Will be furnished by Owner **OR** Number and type of compressed-air cylinders required for complete manifold systems, **as directed**.
5. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
6. Mounting: Wall with mounting brackets for manifold control cabinet and headers **OR** Floor with support legs for manifold control cabinet, **as directed**.
7. Label manifold control unit with permanent label identifying compressed air and system operating pressure.
8. Medical Air Manifolds: For 4 cylinders and 1250-cu. ft./h (9.85-L/s) **OR** 8 cylinders and 2500-cu. ft./h (19.7-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure.
9. Instrument Air Manifolds: For 8 cylinders and 2000-cu. ft./h (15.7-L/s) **OR** 12 cylinders and 3000-cu. ft./h (23.6-L/s), **as directed**, capacity at 200-psig (1380-kPa) minimum line pressure.

G. Medical Compressed-Air-Piping Alarm Systems
1. Panels for medical compressed-air piping systems may be combined in single panels with medical vacuum and medical gas piping systems.
2. Components: Designed for continuous service and to operate on power supplied from 120 **OR** 240 **OR** 277, **as directed**,-V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.
3. Dew Point Monitors: Continuous line monitoring, having panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, factory- or field-installed valved bypass, and visual and cancelable audio signal for dryer site and master alarm panels. Alarm signals when pressure dew point rises above 39 deg F (4 deg C) at 55 psig (380 kPa).
   a. Operation: Chilled-mirror method **OR** Chilled-mirror method or hygrometer moisture analyzer with sensor probe **OR** Hygrometer moisture analyzer with sensor probe, **as directed**.
4. Pressure Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
   a. Low-Pressure Operating Range: 0- to 100-psig (0- to 690-kPa).
   b. High-Pressure Operating Range: Up to 250-psig (1725-kPa).
5. Carbon Monoxide Monitors: Panel with gage or digital display, pipeline sensing element, electrical connections for alarm system, and factory- or field-installed valved bypass. Alarm signals when carbon monoxide level rises above 10 ppm.
6. General Requirements for Medical Compressed-Air Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
   a. Mounting: Exposed, surface **OR** Recessed, **as directed**, installation.
   b. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.
7. Master Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.

a. Include alarm signals when the following conditions exist:
   1) Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 39 deg F (4 deg C) at 55 psig (380 kPa), carbon monoxide level rises above 10 ppm, and high water level is reached in receiver for liquid-ring, medical air compressor systems.
   2) Dental Air: Pressure drops below 65 psig (450 kPa) or rises above 110 psig (760 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 50 deg F (10 deg C) at 125 psig (860 kPa), and carbon monoxide level rises above 10 ppm.
   3) Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).
   4) Medical Laboratory Air: Pressure drops below 90 psig (630 kPa) or rises above 110 psig (760 kPa).

8. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
   a. Include alarm signals when the following conditions exist:
      1) Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
      2) Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).

9. Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
   a. Include alarm signals when the following condition exists:
      1) Medical Air: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).

10. Dental-Area Alarm Panels: Separate trouble alarm signals, pressure gages, and indicators for medical compressed-air piping systems.
    a. Include alarm signals when the following conditions exist:
       1) Dental Air: Pressure drops below 65 psig (450 kPa) or rises above 110 psig (760 kPa), backup air compressor is in operation, pressure drop across filter assembly increases more than 2 psig (13.8 kPa), dew point rises above 50 deg F (10 deg C) at 125 psig (860 kPa), and carbon monoxide level rises above 10 ppm.
       2) Instrument Air: Pressure drops below 165 psig (1140 kPa) or rises above 185 psig (1275 kPa).

11. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals, pressure gages,; and indicators for medical compressed-air piping systems.
    a. Include alarm signals when the following condition exists:
       1) Medical Laboratory Air: Pressure drops below 90 psig (630 kPa) or rises above 110 psig (760 kPa).

H. Computer Interface Cabinet
   1. Description: Wall-mounting, welded-steel control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical compressed-air- piping-system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20, **as directed**, alarm signals.

I. Compressed-Air-Cylinder Storage Racks
   1. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.
   2. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.

J. Flexible Pipe Connectors
   1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
      a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
      b. End Connections: Threaded copper pipe or plain-end copper tube.

K. Sleeves
   1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
   2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
      a. Underdeck Clamp: Clamping ring with set screws.

L. Escutcheons
   1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
   2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
   3. One-Piece, Cast-Brass Escutcheons: With set screw.
      a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
   4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
      a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
   5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
   6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
   7. One-Piece, Floor-Plate Escutcheons: Cast iron.
   8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

M. Grout
   1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
      a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
      b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
      c. Packaging: Premixed and factory packaged.

N. Nitrogen
   1. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

1.3 EXECUTION

A. Piping Applications
   1. Connect new tubing to existing tubing with memory-metal couplings.
   2. Laboratory Air Piping: Use one of the following piping materials for each size range:
      a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
      b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas tube; press-type fittings; and pressure-sealed joints.
      c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
   3. Medical Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.

4. Dental Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
5. Instrument Air Piping:
   a. NPS 3 (DN 80) and Smaller: Use Type K **OR** Type L, **as directed**, copper medical gas tube; wrought-copper fittings; and brazed joints.
   b. NPS 3-1/2 (DN 90) and Larger: Use Type K, copper medical gas tube; wrought-copper fittings; and brazed joints.
6. Medical Laboratory Air Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
7. Drain Piping: Use one of the following piping materials:
   a. Copper water tube, cast- or wrought-copper fittings, and soldered **OR** press-type fittings, and pressure-sealed, **as directed**, joints.
   b. PVC pipe, PVC fittings, and solvent-cemented joints.

B. Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Comply with ASSE Standard #6010 for installation of compressed-air piping.
3. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
6. Install piping adjacent to equipment and specialties to allow service and maintenance.
7. Install air and drain piping with 1 percent slope downward in direction of flow.
8. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.
9. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
10. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
11. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 15 Section "Meters And Gages For Plumbing Piping".
12. Install piping to permit valve servicing.
13. Install piping free of sags and bends.
14. Install fittings for changes in direction and branch connections.
15. Install medical compressed-air piping to medical compressed-air service connections specified in this Section, to medical compressed-air service connections in equipment specified in Division 15 Section "Gas Piping For Laboratory And Healthcare Facilities", and to equipment specified in other Sections requiring medical compressed-air service.
16. Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
17. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
18. Connect compressed-air piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.
19. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

C. Valve Installation
   1. Install shutoff valve at each connection to and from compressed-air equipment and specialties.
   2. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.
   3. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
   4. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
   5. Install safety valves on compressed-air receivers where required by NFPA 99 and where recommended by specialty manufacturers.
   6. Install pressure regulators on compressed-air piping where reduced pressure is required.
   7. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.
   8. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter, **as directed**, of each air compressor.

D. Joint Construction
   1. Ream ends of PVC pipes and remove burrs.
   2. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
   3. Threaded Joints: Apply appropriate tape to external pipe threads.
   4. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.
   5. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.
   6. Pressure-Sealed Joints: Join copper tube and press-type fittings with tools recommended by fitting manufacturer.
   7. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
   8. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:
      a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
      b. Apply primer and join according to ASME B31.9 for solvent-cemented joints, and ASTM D 2672.

E. Compressed-Air Service Component Installation
   1. Install compressed-air pressure control panel in walls. Attach to substrate.
   2. Install compressed-air manifolds on concrete base, **as directed**, anchored to substrate.
   3. Install compressed-air cylinders and connect to manifold piping.
   4. Install compressed-air manifolds with seismic restraints as indicated.
   5. Install compressed-air-cylinder wall storage racks attached to substrate.

F. Medical Compressed-Air-Piping Alarm System Installation
   1. Alarm panels for medical compressed-air piping systems may be combined in single panels with medical vacuum piping systems and medical gas piping systems.
   2. Install alarm system components for medical compressed-air-piping according to and in locations required by NFPA 99.
   3. Install area and master alarm panels for medical compressed-air piping system where indicated.
   4. Install computer interface cabinet with connection to medical compressed-air-piping alarm system and to facility computer.

G. Sleeve Installation
   1. Sleeves are not required for core-drilled holes.
   2. Permanent sleeves are not required for holes formed by removable PE sleeves.

3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
   a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
   b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

   OR

   Install sleeves in new walls and slabs as new walls and slabs are constructed.
4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger penetrating gypsum board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
      1) Seal space outside of sleeve fittings with grout.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

H. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   a. New Piping:
      1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
      2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
      3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.
      4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
      5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
      6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
   b. Existing Piping:
      1) Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
      2) Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
      3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.

4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

I. Hanger And Support Installation
1. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
2. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
3. Vertical Piping: MSS Type 8 or 42, clamps.
4. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for trapeze hangers.
6. Base of Vertical Piping: MSS Type 52, spring hangers.
7. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
8. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
9. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
   h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
   i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
   j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
   k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
   l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
   m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
   n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.
10. Install supports for vertical copper tubing every 10 feet (3 m).

J. Labeling And Identification
1. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 15 Section "Identification For Plumbing Piping And Equipment".
2. Install identifying labels and devices for medical compressed-air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
   a. Medical Air: Black letters on yellow background.

b. Dental Air: Black letters on yellow-and-white diagonal stripe background.
c. Instrument Air: White letters on red background.
d. Medical Laboratory Air: Black letters on yellow-and-white checkerboard background.

K. Field Quality Control For Compressed-Air Piping In Nonmedical Laboratory Facilities
1. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.
2. Tests and Inspections:
a. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
b. Repair leaks and retest until no leaks exist.
c. Inspect filters and pressure regulators for proper operation.

L. Field Quality Control For Medical Compressed-Air Piping In Healthcare Facilities
1. Perform tests and inspections of medical compressed-air piping systems in healthcare facilities and prepare test reports.
2. Tests and Inspections:
a. Medical Compressed-Air Testing Coordination: Perform tests, inspections, verifications, and certification of medical compressed-air piping systems concurrently with tests, inspections, and certification of medical vacuum piping and medical gas piping systems.
b. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
1) Initial blowdown.
2) Initial pressure test.
3) Cross-connection test.
4) Piping purge test.
5) Standing pressure test for positive-pressure medical compressed-air piping.
6) Repair leaks and retest until no leaks exist.
c. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical compressed-air piping systems and perform the following tests and inspections:
1) Standing pressure test.
2) Individual-pressurization **OR** Individual-pressurization or pressure-differential **OR** Pressure-differential, **as directed**, cross-connection test.
3) Valve test.
4) Master and area alarm tests.
5) Piping purge test.
6) Piping particulate test.
7) Piping purity test.
8) Final tie-in test.
9) Operational pressure test.
10) Medical air purity test.
11) Verify correct labeling of equipment and components.
d. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
1) Inspections performed.
2) Procedures, materials, and gases used.
3) Test methods used.
4) Results of tests.
3. Remove and replace components that do not pass tests and inspections and retest as specified above.

END OF SECTION 15063

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SECTION 15063a - VACUUM PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for vacuum piping for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Laboratory low-vacuum piping and specialties, designated "laboratory low vacuum" operating at 12 inches mercury (40.6 kPa vacuum) **OR** 20 inches mercury (67.7 kPa vacuum), **as directed**.
b. Laboratory high-vacuum piping and specialties, designated "laboratory high vacuum" operating at 24 inches mercury (81.3 kPa vacuum) **OR** 29 inches mercury (98.2 kPa vacuum), **as directed**.
c. Medical surgical vacuum piping and specialties, designated "medical vacuum" operating at 15 inches mercury (380 mm mercury or 50.7 kPa vacuum) **OR** 20 inches mercury (510 mm mercury or 67.7 kPa vacuum) **OR** 30 inches mercury (760 mm mercury or 101.4 kPa vacuum), **as directed**.
d. Waste anesthetic gas disposal piping and specialties, designated "WAGD evacuation" operating at 14 inches mercury (355 mm mercury or 47.2 kPa vacuum) **OR** 15 inches mercury (380 mm mercury or 50.7 kPa vacuum), **as directed**.
e. Dental vacuum piping and specialties, designated "dental vacuum" operating at 10 inches mercury (255 mm mercury or 33.8 kPa vacuum) **OR** 12 inches mercury (305 mm mercury or 40.6 kPa vacuum), **as directed**.
f. Oral-evacuation piping and specialties, designated "HVE" operating at 5 inches mercury (127 mm mercury or 16.9 kPa vacuum) **OR** 8 inches mercury (203 mm mercury or 27.0 kPa vacuum), **as directed**.
g. Healthcare laboratory vacuum piping and specialties, designated "medical laboratory vacuum" operating at 12 inches mercury (40.6 kPa vacuum) **OR** 20 inches mercury (67.7 kPa vacuum) **OR** 24 inches mercury (81.3 kPa vacuum), **as directed**.

C. Definitions
1. D.I.S.S.: Diameter-index safety system.
2. HVE: High-volume (oral) evacuation.
3. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
4. WAGD: Waste anesthetic gas disposal.
5. Medical vacuum piping systems include medical vacuum, WAGD evacuation, dental vacuum, HVE, and medical laboratory vacuum piping systems.

D. Submittals
1. Product Data: For the following:
a. Vacuum pipes **OR** tubes, **as directed**, and fittings.
b. Vacuum valves and valve boxes.
c. Medical vacuum service connections and vacuum-bottle brackets.
2. LEED Submittal:
a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: Diagram power, signal, and control wiring.

4. Piping Material Certification: Signed by Installer certifying that medical vacuum piping materials comply with NFPA 99 requirements.
5. Qualification Data: For Installer and testing agency.
6. Brazing certificates.
7. Field quality-control test reports.
8. Operation and maintenance data.

E. Quality Assurance
1. Installer Qualifications:
   a. Medical Vacuum Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010.
   b. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by T-DRILL Industries Inc., for making branch outlets.
   c. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.
2. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
   a. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
3. Source Limitations: Obtain vacuum service connections of same type and from same manufacture as service connections provided for in Division 15 Section "Gas Piping For Laboratory And Healthcare Facilities".
4. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
6. Comply with ASME B31.9, "Building Services Piping," for vacuum piping in laboratory facilities.
7. NFPA Compliance: Comply with NFPA 99, "Health Care Facilities," for medical vacuum system materials and installation in healthcare facilities.

F. Project Conditions
1. Interruption of Existing Laboratory or Medical Vacuum Service(s): Do not interrupt laboratory or medical vacuum service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of laboratory or medical vacuum service(s).
   b. Do not proceed with interruption of laboratory or medical vacuum service(s) without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings
1. Copper Medical Gas Tube: ASTM B 819, Type L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in blue.
   a. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.

b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
c. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
d. Press-Type Fittings:
1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

2. Copper Water Tube: ASTM B 88, Type M (ASTM B 88M, Type C), seamless, drawn temper.
a. Cast-Copper Fittings: ASME B16.18, solder-joint pressure type.
b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type.
c. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
d. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
e. Press-Type Fittings:
1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.

3. Extruded-Tee Outlets: ASTM F 2014 procedure for making branch outlets in copper tube.
4. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.
5. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
a. PVC Pressure Fittings: ASTM D 2466, Schedule 40 and ASTM D 2467, Schedule 80; socket type.

B. Joining Materials
1. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
2. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
3. Threaded-Joint Tape: PTFE.
4. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness, full-face type.
5. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
6. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.
a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Valves
1. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
a. Exception: Factory cleaning and bagging are not required for valves for WAGD service.
2. Copper-Alloy Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
a. Pressure Rating: 300 psig (2070 kPa) minimum.
b. Ball: Full-port, chrome-plated brass.
c. Seats: PTFE or TFE.
d. Handle: Lever type with locking device, **as directed**.
e. Stem: Blowout proof with PTFE or TFE seal.
f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
3. Bronze Check Valves: In-line pattern.
a. Pressure Rating: 300 psig (2070 kPa) minimum.
b. Operation: Spring loaded.

c. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.

4. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Ball: Full-port, chrome-plated brass.
   c. Seats: PTFE or TFE.
   d. Handle: Lever type with locking device, **as directed**.
   e. Stem: Blowout proof with PTFE or TFE seal.
   f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
   g. Vacuum Gage: Manufacturer installed on one copper-tube extension.
5. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with vacuum gages and in sizes required to permit manual operation of valves.
   a. Interior Finish: Factory-applied white enamel.
   b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Satin-chrome finish steel **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
   c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
6. Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with vacuum gages and in sizes required to permit manual operation of valves.
   a. Interior Finish: Factory-applied white enamel.
   b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.
   c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.
7. PVC Ball Valves: MSS SP-122, with union ends and 150-psig (1035-kPa) minimum working-pressure rating and suitable for vacuum service.
8. PVC Butterfly Valves: Lug type with lever handle and 150-psig (1035-kPa) minimum working-pressure rating and suitable for vacuum service.
9. PVC Check Valves: Ball-, in-line-, piston-, or swing-check design with flanged or union ends and 70-psig (480-kPa) **OR** 100-psig (690-kPa), **as directed**, minimum working-pressure rating and suitable for vacuum service.
10. Safety Valves: Bronze-body, ASME-construction, pressure-relief type with settings to match system requirements.
11. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated.

D. Medical Vacuum Service Connections
   1. Connection Devices: For specific medical vacuum service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.
      a. Roughing-in Assembly:
         1) Steel outlet box for recessed mounting and concealed piping.
         2) Brass-body inlet block.
         3) Seals that will prevent vacuum leakage.
         4) ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.
      b. Finishing Assembly:
         1) Brass housing with primary check valve.
         2) Seals that will prevent vacuum leakage.
         3) Cover plate with gas-service label.

c. Quick-Coupler Service Connections: Suction inlets for medical vacuum **OR** medical vacuum and WAGD evacuation **OR** WAGD evacuation, **as directed**, service outlets with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

d. D.I.S.S. Service Connections: Suction inlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

1) Medical Vacuum Service Connections: CGA V-5, D.I.S.S. No. 1220.

2) WAGD Evacuation Service Connections: CGA V-5, D.I.S.S. No. 2220.

e. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.

f. Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent, color-coded, identifying label matching corresponding service.

E. Medical Vacuum Piping Alarm Systems

1. Panels for medical vacuum piping systems may be combined in single panels with medical compressed-air and medical gas piping systems.

2. Components: Designed for continuous service and to operate on power supplied from 120-V **OR** 240-V **OR** 277-V, **as directed**, ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.

3. Vacuum Switches or Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.

a. Vacuum Operating Range: 0- to 30-in. Hg (0- to 101-kPa vacuum).

4. General Requirements for Medical Vacuum Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.

a. Mounting: Exposed, surface **OR** Recessed, **as directed**, installation.

b. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.

5. Master Alarm Panels: With separate trouble alarm signals, vacuum gages, and indicators for medical vacuum piping systems.

a. Include alarm signals when the following conditions exist:

1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum) and backup vacuum pump is in operation.

2) WAGD Evacuation: Vacuum drops below 12-in. Hg (40 kPa vacuum).

3) Dental Vacuum: Vacuum drops below 6-in. Hg (20 kPa vacuum) and backup vacuum producer is in operation.

4) HVE: 4-in. Hg (13 kPa vacuum) and backup vacuum producer is in operation.

5) Medical Laboratory Vacuum: Vacuum drops below 10-in. Hg (34 kPa vacuum).

6. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.

a. Include alarm signals when the following conditions exist:

1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum).

2) WAGD Evacuation: Vacuum drops below 12-in. Hg (40 kPa vacuum).

7. Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.

a. Include alarm signals when the following condition exists:

1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum).

8. Dental Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.

a. Include alarm signals when the following conditions exist:

1) Dental Vacuum: Vacuum drops below 6-in. Hg (20 kPa vacuum) and backup vacuum producer is in operation.

2) HVE: 4-in. Hg (13 kPa vacuum) and backup vacuum producer is in operation.

9. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals; vacuum gages; and indicators for medical vacuum piping systems.
   a. Include alarm signals when the following condition exists:
      1) Medical Vacuum: Vacuum drops below 12-in. Hg (40 kPa vacuum).

F. Computer Interface Cabinet
1. Description: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical vacuum piping system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20 alarm signals.

G. Flexible Pipe Connectors
1. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   a. Working-Pressure Rating: 200 psig (1380 kPa) **OR** 250 psig (1725 kPa), **as directed**, minimum.
   b. End Connections: Threaded copper pipe or plain-end copper tube.

H. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

I. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Escutcheons: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass **OR** Polished chrome-plated and rough brass, **as directed**.
5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Escutcheons: Cast iron.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

J. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
   c. Packaging: Premixed and factory packaged.

K. Nitrogen
1. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

1.3 EXECUTION

A. Preparation

1. Cleaning of Medical Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
   a. Clean medical gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
   b. Wash medical gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb (0.453 kg) of chemical to 3 gal. (11.3 L) of water.
      1) Scrub to ensure complete cleaning.
      2) Rinse with clean, hot water to remove cleaning solution.

B. Piping Applications

1. Connect new copper tubing to existing tubing with memory-metal couplings.
2. Nonhealthcare Laboratory Low Vacuum Piping: Use one of the following piping materials for each size range:
   a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
   b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
   c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
3. Nonhealthcare Laboratory High Vacuum Piping: Use one of the following piping materials for each size range:
   a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
   b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
   c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
4. Medical Vacuum Piping: Use one of the following piping materials for each size range:
   a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
   b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
   c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
5. WAGD Evacuation Piping: Use one of the following piping materials for each size range:
   a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
   b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
   c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
6. Dental Vacuum Piping: Use one of the following piping materials for each size range:
   a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
   b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
   c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
7. HVE Piping: Use one of the following piping materials for each size range:

a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
c. NPS 4 (DN 100) and Smaller: Schedule 40 PVC pipe, Schedule 40 PVC fittings **OR** Schedule 80 PVC pipe, Schedule 80 PVC fittings, **as directed**, and solvent-cemented joints.
d. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed **OR** soldered, **as directed**, joints.
e. NPS 5 to NPS 8 (DN 125 to DN 200): Schedule 40 PVC pipe, Schedule 40 PVC fittings **OR** Schedule 80 PVC pipe, Schedule 80 PVC fittings, **as directed**, and solvent-cemented joints.

8. Medical Laboratory Vacuum Piping: Use one of the following piping materials for each size range:
   a. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
   b. NPS 4 (DN 100) and Smaller: Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; press-type fittings; and pressure-sealed joints.
   c. NPS 5 to NPS 8 (DN 125 to DN 200): Type L, copper medical gas **OR** M (C) copper water, **as directed**, tube; wrought-copper fittings; and brazed joints.
9. Drain Piping: Use one of the following piping materials:
   a. Copper water tube, cast- or wrought-copper fittings, and soldered **OR** press-type fittings, and pressure-sealed, **as directed**, joints.
   b. PVC pipe, PVC fittings, and solvent-cemented joints.

C. Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Comply with ASSE Standard #6010 for installation of vacuum piping.
3. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
6. Install piping adjacent to equipment and specialties to allow service and maintenance.
7. Install vacuum and drain piping with 1 percent slope downward in direction of flow.
8. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications below unless otherwise indicated.
9. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
10. Provide drain leg and drain trap at end of each main and branch and at low points.
11. Install thermometer and vacuum gage on inlet piping to each vacuum producer and on each receiver and separator, **as directed**. Comply with requirements in Division 15 Section "Meters And Gages For Plumbing Piping".
12. Install piping to permit valve servicing.
13. Install piping free of sags and bends.
14. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.
15. Install medical vacuum piping to medical vacuum service connections specified in this Section and to equipment specified in other Sections requiring medical vacuum service.

16. Install seismic restraints on vacuum piping. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
17. Install medical vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
18. Install medical vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.
19. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.
20. Install unions, in copper vacuum tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.
21. Install unions, in PVC vacuum piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.
22. Install flanges, in PVC vacuum piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment, machine, and specialty.

D. Valve Applications
1. Valves for Copper Vacuum Tubing: Use copper alloy ball and bronze check types.
2. Valves for PVC Vacuum Piping:
   a. NPS 4 (DN 100) and Smaller: Use copper alloy ball and bronze **OR** PVC ball, butterfly, and, **as directed**, check types.
   b. NPS 5 (DN 125) and Larger: Use PVC butterfly and check types.

E. Valve Installation
1. Install shutoff valve at each connection to and from vacuum equipment and specialties.
2. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.
3. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
4. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
5. Install safety valves on vacuum receivers, where required by NFPA 99, and where recommended by specialty manufacturers.
6. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain, so contents spill over or into it.
7. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

F. Joint Construction
1. Ream ends of pipes and tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
3. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
4. Threaded Joints: Apply appropriate tape to external pipe threads.
5. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.
6. Soldered Joints: Apply ASTM B 813, water-flushable flux to tube end. Join copper tube and fittings according to ASTM B 828.
7. Extruded-Tee Outlets: Form branches in copper tube according to ASTM F 2014, with tools recommended by procedure manufacture.
8. Flanged Joints:
   a. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
   b. PVC Piping: Install PVC flange on PVC pipes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
9. Pressure-Sealed Joints: Join copper tube and copper and copper-alloy fittings with tools recommended by fitting manufacturer.
10. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
11. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:

a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
b. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2672.

G. Medical Vacuum Piping Alarm System Installation
1. Panels for medical vacuum piping systems may be combined in single panels with medical compressed-air piping systems and medical gas piping systems.
2. Install medical vacuum piping system alarm system components in locations required by and according to NFPA 99.
3. Install medical vacuum piping system area and master alarm panels where indicated.
4. Install computer interface cabinet with connection to medical vacuum piping alarm system and to facility computer.

H. Sleeve Installation
1. Sleeves are not required for core-drilled holes.
2. Permanent sleeves are not required for holes formed by removable PE sleeves.
3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
   a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
   b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

   OR

   Install sleeves in new walls and slabs as new walls and slabs are constructed.
4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
      1) Seal space outside of sleeve fittings with grout.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

I. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   a. New Piping:
      1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
      2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
      3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One-piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.

4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

b. Existing Piping:
1) Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2) Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

J. Hanger And Support Installation
1. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
2. Vertical Piping: MSS Type 8 or 42, clamps.
3. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.
4. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for trapeze hangers.
5. Base of Vertical Piping: MSS Type 52, spring hangers.
6. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
7. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
8. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
   h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
   i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
   j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.
   k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
   l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.

m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.

9. Install supports for vertical copper tubing every 10 feet (3 m).
10. Install hangers **OR** vinyl-coated hangers, **as directed**, for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1 (DN 25) and Smaller: 30 inches (760 mm) with 3/8-inch (10-mm) rod.
    b. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): 36 inches (900 mm) with 3/8-inch (10-mm) rod.
    c. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1150 mm) with 1/2-inch (13-mm) rod.
    d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 1/2-inch (13-mm) rod.
    e. NPS 6 and NPS 8 (DN 150 and DN 200): 54 inches (1350 mm) with 5/8-inch (16-mm) rod.
11. Install supports for vertical PVC piping every 48 inches (1220 mm).

K. Labeling And Identification
1. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Division 15 Section "Identification For Plumbing Piping And Equipment".
2. Install identifying labels and devices for medical vacuum piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
    a. Medical Vacuum: Black letters on white background.
    b. WAGD: White letters on violet background.
    c. Dental Vacuum: Black boxed letters on white-and-black diagonal stripe background.
    d. HVE: Black boxed letters on white-and-black diagonal stripe background.
    e. Medical Laboratory Vacuum: Black boxed letters on white-and-black checkerboard background.

L. Field Quality Control For Laboratory Facility Nonmedical Vacuum Piping
1. Perform tests and inspections of vacuum piping in nonmedical laboratory facilities.
2. Tests and Inspections:
    a. Piping Leak Tests for Vacuum Piping: Test new and modified parts of existing piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
        1) Test Pressure for Copper Tubing: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.
        2) Test Pressure for PVC Piping: 50 psig (345 kPa) **OR** 100 psig (690 kPa), **as directed**.
    b. Repair leaks and retest until no leaks exist.
    c. Inspect filters for proper operation.
3. Prepare test reports.

M. Field Quality Control For Healthcare Facility Medical Vacuum Piping
1. Perform tests and inspections of medical vacuum piping systems in healthcare facilities and prepare test reports.
2. Tests and Inspections:
    a. Medical Vacuum Testing Coordination: Perform tests, inspections, verifications, and certification of medical vacuum piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical gas piping systems.
    b. Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
        1) Initial blow down.
        2) Initial pressure test.
        3) Cross-connection test.
        4) Piping purge test.

5) Standing pressure test for vacuum systems.
6) Repair leaks and retest until no leaks exist.

c. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical vacuum piping systems and perform the following tests and inspections:
1) Standing pressure test.
2) Individual-pressurization **OR** Pressure-differential, **as directed**, cross-connection test.
3) Valve test.
4) Master and area alarm tests.
5) Piping purge test.
6) Final tie-in test.
7) Operational vacuum test.
8) Verify correct labeling of equipment and components.

d. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
1) Inspections performed.
2) Procedures, materials, and gases used.
3) Test methods used.
4) Results of tests.

3. Remove and replace components that do not pass tests and inspections and retest as specified above.

N. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain medical vacuum alarm systems.

END OF SECTION 15063a

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SECTION 15063b - GAS PIPING FOR LABORATORY AND HEALTHCARE FACILITIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for gas piping for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Carbon dioxide piping and specialties designated "medical carbon dioxide" operating at 50 to 55 psig (345 to 380 kPa).
b. Helium piping, designated "medical helium" operating at 50 to 55 psig (345 to 380 kPa).
c. Nitrogen piping and specialties designated "medical nitrogen" operating at 160 to 185 psig (1100 to 1275 kPa) **OR** higher than 200 psig (1380 kPa), **as directed**.
d. Nitrous oxide piping and specialties designated "medical nitrous oxide" operating at 50 to 55 psig (345 to 380 kPa).
e. Oxygen piping and specialties designated "medical oxygen" operating at 50 to 55 psig (345 to 380 kPa).

C. Definitions
1. CR: Chlorosulfonated polyethylene synthetic rubber.
2. D.I.S.S.: Diameter-index safety system.
3. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
4. Medical gas piping systems include medical carbon dioxide, medical helium, medical nitrogen, medical nitrous oxide, and medical oxygen nonflammable gas for healthcare facility patient care or for healthcare laboratory applications.
5. Specialty Gas: Gas, other than medical gas, for nonmedical laboratory facility applications.

D. Performance Requirements
1. Seismic Performance: Gas manifolds, Bulk gas storage tanks, Gas manifolds and bulk gas storage tanks, and piping shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

E. Submittals
1. Product Data: For the following:
a. Tubes and fittings.
b. Valves and valve boxes.
c. Medical gas service connections.
d. Electrical service connections.
e. Patient service consoles.
f. Medical nitrogen pressure control panels.
g. Ceiling columns. Include integral service connections.
h. Ceiling hose assemblies. Include integral service connections.
i. Gas manifolds.
j. Bulk gas storage tanks. Include rated capacities and operating weights.
k. Medical gas alarm system components.
l. Gas cylinder storage racks.
2. Shop Drawings: Diagram power, signal, and control wiring.

3. Piping Material Certification: Signed by Installer certifying that medical gas piping materials comply with NFPA 99 requirements.
4. Brazing certificates.
5. Manufacturer Seismic Qualification Certification: Submit certification that gas manifolds and bulk gas storage tanks, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment". Include the following:
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
6. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code.
7. Field quality-control test reports.
8. Operation and maintenance data.

F. Quality Assurance
1. Installer Qualifications:
   a. Medical Gas Piping Systems for Healthcare Facilities: Qualify installers according to ASSE Standard #6010 for installers.
2. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the medical gas piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   a. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
3. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications"; or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. ASME Compliance: Fabricate and label bulk medical gas storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
6. NFPA Compliance:
   a. Comply with NFPA 50, "Bulk Oxygen Systems at Consumer Sites," for bulk oxygen storage tanks.
   b. Comply with NFPA 99, "Health Care Facilities," for medical gas piping system materials and installation.
7. CGA Compliance: Comply with CGA G-8.1, "Nitrous Oxide Systems at Consumer Sites," for bulk nitrous oxide storage tanks.
8. UL Compliance:
   a. Comply with UL 498, "Attachment Plugs and Receptacles," for electrical service connections.
   b. Comply with UL 544, "Medical and Dental Equipment," for medical gas specialties.

G. Project Conditions
1. Interruption of Existing Specialty and Medical Gas Service(s): Do not interrupt specialty or medical gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of specialty and medical gas service(s).
   b. Do not proceed with interruption of specialty and medical gas service(s) without Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings
1. Copper Medical Gas Tube: ASTM B 819, Type K **OR** Type L, **as directed**, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service or according to CGA G-4.1 for oxygen service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and blue for Type L tube.
   a. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
   b. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
   c. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
   d. Press-Type Fittings:
      1) NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
      2) NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
   e. Memory-Metal Couplings: Cryogenic compression fitting made of ASTM F 2063, nickel-titanium, shape-memory-alloy, and that has been manufacturer cleaned, purged, and sealed for oxygen service according to CGA G-4.1.
2. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
   a. PVC Fittings: ASTM D 2466, Schedule 40 **OR** ASTM D 2467, Schedule 80, **as directed**; socket type.

B. Joining Materials
1. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys.
2. Threaded-Joint Tape: PTFE.
3. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.

C. Valves
1. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
2. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Ball: Full-port, chrome-plated brass.
   c. Seats: PTFE or TFE.
   d. Handle: Lever type with locking device, **as directed**.
   e. Stem: Blowout proof with PTFE or TFE seal.
   f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
3. Check Valves: In-line pattern, bronze.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Operation: Spring loaded.
   c. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
4. Zone Valves: MSS SP-110, 3-piece-body, brass or bronze ball valve with gage.
   a. Pressure Rating: 300 psig (2070 kPa) minimum.
   b. Ball: Full-port, chrome-plated brass.
   c. Seats: PTFE or TFE.
   d. Handle: Lever type with locking device, **as directed**.
   e. Stem: Blowout proof with PTFE or TFE seal.
   f. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
   g. Pressure Gage: Manufacturer-installed on one copper-tube extension.
5. Zone Valve Boxes: Formed steel with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.
   a. Interior Finish: Factory-applied white enamel.

b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Satin-chrome finish steel **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.

c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

OR

Zone Valve Boxes: Formed or extruded aluminum with anchors for recessed mounting, holes with grommets in box sides for tubing extension protection, and of size for single or multiple valves with pressure gages and in sizes required to permit manual operation of valves.

a. Interior Finish: Factory-applied white enamel.

b. Cover Plate: Aluminum or extruded-anodized aluminum **OR** Stainless steel with NAAMM AMP 503, No. 4 finish, **as directed**, with frangible or removable windows.

c. Valve-Box Windows: Clear or tinted transparent plastic with labeling that includes rooms served, according to NFPA 99.

6. Emergency Oxygen Connections: Low-pressure oxygen inlet assembly for connection to building oxygen piping systems.

a. Enclosure: Weatherproof hinged locking cover with caption similar to "Emergency Low-Pressure Gaseous Oxygen Inlet."

b. Inlet: Manufacturer-installed, NPS 1 or NPS 1-1/4 (DN 25 or DN 32), ASTM B 819, copper tubing with NPS 1 (DN 25) minimum ball valve and plugged inlet.

c. Safety Valve: Bronze-body, pressure relief valve set at 75 or 80 psig (520 or 550 kPa).

d. Instrumentation: Pressure gage.

7. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.

8. Pressure Regulators: Bronze **OR** Stainless-steel, **as directed**, body and trim; spring-loaded, diaphragm-operated, relieving type; manual pressure-setting adjustment; rated for 250-psig (1725-kPa) minimum inlet pressure; and capable of controlling delivered gas pressure within 0.5 psig for each 10-psig (5.0 kPa for each 100-kPa) inlet pressure.

D. Medical Gas Service Connections

1. General Requirements for Medical Gas Service Connections: For specific medical gas pressure and suction service listed. Include roughing-in assemblies, finishing assemblies, and cover plates. Individual cover plates are not required if service connection is in multiple unit or assembly with cover plate. Furnish recessed-type units made for concealed piping unless otherwise indicated.

a. Roughing-in Assembly:

1) Steel outlet box for recessed mounting and concealed piping.

2) Brass-body outlet block with secondary check valve that will prevent gas flow when primary valve is removed. Suction inlets to be without secondary valve.

3) Double seals that will prevent gas leakage.

4) ASTM B 819, NPS 3/8 (DN 10) copper outlet tube brazed to valve with service marking and tube-end dust cap.

b. Finishing Assembly:

1) Brass housing with primary check valve.

2) Double seals that will prevent gas leakage.

3) Cover plate with gas-service label.

c. Quick-Coupler Service Connections: Pressure outlets for carbon dioxide, nitrous xide, oxygen, and <**Insert medical gas**> service connections with noninterchangeable keyed indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment, and with positive-locking ring that retains equipment stem in valve during use.

d. D.I.S.S. Service Connections: Pressure outlets, complying with CGA V-5, with threaded indexing to prevent interchange between services, constructed to permit one-handed connection and removal of equipment.

1) Medical Carbon Dioxide Service Connections: D.I.S.S. No. 1080.

2) Medical Helium Service Connections: D.I.S.S. No. 1060.
3) Medical Nitrogen Service Connections: D.I.S.S. No. 1120.
4) Medical Nitrous Oxide Service Connections: D.I.S.S. No. 1040.
5) Medical Oxygen Service Connections: D.I.S.S. No. 1240.

e. Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent, color-coded, identifying label matching corresponding service.

E. Electrical Service Connections

1. Power Outlets: UL 498, Hospital Grade, 125-V receptacles; color selected. Include the following configurations complying with NEMA WD 1:
   a. L5-20R, locking type, 20 A, single or duplex.
   b. L5-20R, isolated ground, locking type, 20 A, single or duplex.
   c. Explosion proof, 20 A, 2 pole, 3 wire, single; suitable for Class I, Group C hazardous location and interchangeable with receptacles used in nonhazardous areas; flush mounted.
   d. 5-20R, straight blade, 20 A, duplex.
   e. 5-20R, isolated ground, straight blade, 20 A, duplex.
2. Electrical Accessory Outlets: Provide the following configured receptacles in color selected:
   a. Patient Equipment Ground Jack: Single pole, 30 A.
   b. Patient Monitoring: Single, 5 and 37 pin.
3. Wall Outlet Cover Plates: One piece, stainless steel, with NAAMM AMP 503, No. 4 finish **OR** metal, with chrome-plated finish **OR** anodized aluminum, **as directed**, and permanent identifying label.

F. Patient Service Consoles

1. General Requirements for Patient Service Consoles: Recessed- or semirecessed-mounting wall units with medical gas service connections as specified in "Medical Gas Service Connections" Article and electrical service connections as specified in "Electrical Service Connections" Article, **as directed**. Include labels indicating services, and the following:
   a. Recessed- or semirecessed-mounting steel console box or mounting bracket.
   b. Concealed supplies.
   c. Cover Plate: One piece, anodized aluminum **OR** stainless steel, **as directed**, and permanent identifying label with service connections for the following:
      1) Medical Air: Quick-coupler pressure outlet.
      2) Medical Oxygen: Quick-coupler pressure outlet.
      3) Medical Vacuum: Quick-coupler suction inlet.
      4) Medical vacuum bottle bracket.
      5) L5-20R, locking type, 20 A, single **OR** duplex, **as directed**.

G. Medical Nitrogen Pressure Control Panels

1. Description: Steel box and support brackets for recessed roughing-in with stainless-steel or anodized-aluminum cover plate with printed operating instructions. Include manifold assembly consisting of inlet supply valve, inlet supply pressure gage, line-pressure control regulator, outlet supply pressure gage, D.I.S.S. service connection, and piping outlet for remote service connection.
   a. Minimum Working Pressure: 200 psig (1380 kPa).
   b. Line-Pressure Control Regulator: Self-relieving diaphragm type with precision manual adjustment.
   c. Pressure Gages: 0- to 300-psig (0- to 2070-kPa) range.
   d. Service Connection: CGA V-5, D.I.S.S. No. 1120, nitrogen outlet.
   e. Before final assembly, provide temporary dust shield and U-tube for testing.
   f. Label cover plate "Nitrogen Pressure Control."

H. Ceiling Columns

1. General Requirements for Ceiling Columns: Ceiling-mounting units with medical gas service connections as specified in "Medical Gas Service Connections" Article and electrical service

connections as specified in "Electrical Service Connections" Article, **as directed**. Include labels indicating services, and the following:

a. Ceiling-Mounting Plate: Manufacturer's standard plate or roughing-in assembly.
b. Exposed Surfaces: Minimum 0.0375-inch- (0.95-mm-) thick stainless steel with NAAMM AMP 503, No. 4 directional polish.
c. Servicing: Include access panels or means of removing shroud.
d. Blank cover plates for cutouts not having service connections.
e. ASTM B 819, NPS 3/8 (DN 10) copper-tube extensions for connection to medical gas systems.
f. Service Connections: Type and number indicated.
g. Dust Covers: For medical gas service connection.

2. Rigid Ceiling Columns: 44-inch- (1120-mm-) long, rectangular fixed column section with 2 **OR** 4, **as directed**, double intravenous medication hooks. Include 0.078-inch- (2.0-mm-) thick, stainless-steel bottom plate with the following service connections:
   a. Instrument Air: One D.I.S.S. No. 1160 pressure outlet(s).
   b. Medical Air: One quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet(s).
   c. Medical Carbon Dioxide: One quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet(s).
   d. Medical Helium: One D.I.S.S. No. 1060, pressure outlet(s).
   e. Medical Nitrogen: One D.I.S.S. No. 1120 pressure outlet(s).
   f. Medical Nitrous Oxide: One quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet(s).
   g. Medical Oxygen: Two quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlets.
   h. Medical Vacuum: Two quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlets.
   i. Vacuum Bottle Brackets: Two.
   j. WAGD Evacuation: One quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet(s).
   k. Power: 2 **OR** 4, **as directed**, L5-20R, locking-type, 20-A, single receptacles.
   l. Patient Equipment: 2 **OR** 4, **as directed**, ground-jack, single-pole, 30-A receptacles.
3. Retractable Ceiling Columns: Manually adjustable using release and lock handles capable of locking column in all positions from fully retracted to fully extended; 15-inch- (380-mm-) long, rectangular counterbalanced telescoping section with 2 **OR** 4, **as directed**, double intravenous medication hooks; and 36-inch- (915-mm-) long, fixed column section. Include 0.078-inch- (2.0-mm-) thick, stainless-steel bottom plate with the following service connections:
   a. Instrument Air: One D.I.S.S. No. 1160 pressure outlet(s).
   b. Medical Air: One quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet(s).
   c. Medical Carbon Dioxide: One quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet(s).
   d. Medical Helium: One D.I.S.S. No. 1060, pressure outlet(s).
   e. Medical Nitrogen: One D.I.S.S. No. 1120 pressure outlet(s).
   f. Medical Nitrous Oxide: One quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet(s).
   g. Medical Oxygen: Two quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlets.
   h. Medical Vacuum: Two quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlets.
   i. Vacuum Bottle Brackets: Two.
   j. WAGD Evacuation: One quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet(s).
   k. Power: 2 **OR** 4, **as directed**, L5-20R, locking-type, 20-A, single receptacles.
   l. Patient Equipment: 2 **OR** 4, **as directed**, ground-jack, single-pole, 30-A receptacles.

I. Ceiling Hose Assemblies
   1. Ceiling Hose Assemblies, General: Ceiling-mounting units with medical gas service connections as specified in "Medical Gas Service Connections" Article and electrical service connections as specified in "Electrical Service Connections" Article, **as directed**. Include labels indicating services, and the following:
      a. Ceiling-Mounting Plate: Manufacturer's standard plate or roughing-in assembly.

b. Exposed Surfaces: Minimum 0.0375-inch- (0.95-mm-) thick stainless steel with NAAMM AMP 503, No. 4 directional polish.
c. Servicing: Include access panels or means of removing shroud.
d. Blank cover plates for cutouts not having service connections.
e. ASTM B 819, NPS 3/8 (DN 10) copper-tube extensions for connection to medical gas systems.
f. Service Connections: Type and number indicated.
g. Dust Covers: For medical gas service connection.

2. Hose-Reel Service Assemblies: Individual, concealed, retractable hose-reel units with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with adjustable stops and service connections matching hoses. Include 15 feet (4.5 m) minimum of conductive, CR, 1/4- or 5/16-inch- (6.4- or 7.9-mm-) ID, medical gas hoses rated for 200-psig (1380-kPa) minimum working pressure, and the following service connections:
   a. Instrument Air Hose: D.I.S.S. No. 1160 pressure outlet.
   b. Medical Air Hose: Quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet.
   c. Medical Carbon Dioxide Hose: Quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet.
   d. Medical Nitrogen Hose: D.I.S.S. No. 1120 pressure outlet.
   e. Medical Nitrous Oxide Hose: Quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet.
   f. Medical Oxygen Hose: Quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlet.
   g. Medical Vacuum Hose: Quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlet.
   h. WAGD Evacuation Hose: Quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet.
   i. Power: L5-20R, locking-type, 20-A, single, power receptacle.
3. Fixed Hose Service Assemblies: Individual, concealed hose connection with stainless-steel face plates, steel mounting boxes, factory- or field-fabricated mounting brackets, and color-coded service hoses with retractor device and service connections matching hoses. Include 72 inches (1830 mm) of conductive, CR, 1/4- or 5/16-inch- (6.4- or 7.9-mm-), ID, medical gas hoses rated for 200-psig (1380-kPa) minimum working pressure, and the following service hose connections:
   a. Instrument Air Hose: D.I.S.S. No. 1160 pressure outlet.
   b. Medical Air Hose: Quick-coupler **OR** D.I.S.S. No. 1160, **as directed**, pressure outlet.
   c. Medical Carbon Dioxide Hose: Quick-coupler **OR** D.I.S.S. No. 1080, **as directed**, pressure outlet.
   d. Medical Nitrogen Hose: D.I.S.S. No. 1120 pressure outlet.
   e. Medical Nitrous Oxide Hose: Quick-coupler **OR** D.I.S.S. No. 1040, **as directed**, pressure outlet.
   f. Medical Oxygen Hose: Quick-coupler **OR** D.I.S.S. No. 1240, **as directed**, pressure outlet.
   g. Medical Vacuum Hose: Quick-coupler **OR** D.I.S.S. No. 1220, **as directed**, suction inlet.
   h. WAGD Evacuation Hose: Quick-coupler **OR** D.I.S.S. No. 2220, **as directed**, suction inlet.
   i. Power: L5-20R, locking-type, 20-A, single, power receptacle.

J. Gas Manifolds
1. Simplex Specialty Gas Manifolds:
   a. Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.
   b. Manifold and Header: Nonferrous-metal header for number of cylinders indicated. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder bank header with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
   c. <**Insert specialty gas**> Manifold: For <**Insert number cylinders**> capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
   d. Specialty Gas Cylinders: Will be furnished by Owner **OR** Number and type of medical gas cylinders required for complete manifold systems, **as directed**.

e. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
f. Mounting: Wall with mounting brackets for manifold control cabinet and header **OR** Floor with support legs for manifold control cabinet, **as directed**.

2. Duplex Specialty Gas Manifolds:
   a. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, line-pressure regulator, shutoff valves, and safety valve.
   b. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure. Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
   c. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
   d. <**Insert specialty gas**> Manifold: For <**Insert number cylinders**> capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
   e. Specialty Gas Cylinders: Will be furnished by Owner **OR** Number and type of medical gas cylinders required for complete manifold systems, **as directed**.
   f. Label manifold control unit with permanent label identifying specialty gas type and system operating pressure.
   g. Mounting: Wall with mounting brackets for manifold control cabinet and headers **OR** Floor with support legs for manifold control cabinet, **as directed**.
3. Medical Gas Manifolds: Comply with NFPA 99, Ch. 5, for high-pressure medical gas cylinders.
   a. Central Control Panel Unit: Weatherproof cabinet, supply and delivery pressure gages, electrical alarm system connections and transformer, indicator lights or devices, manifold connection, pressure changeover switch, line-pressure regulator, shutoff valves, and safety valve.
   b. Manifold and Headers: Duplex, nonferrous-metal header for number of cylinders indicated, divided into two equal banks. Units include design for 2000-psig (13.8-MPa) minimum inlet pressure, except nitrous oxide manifolds may be designed for 800 psig (5520 kPa) and carbon dioxide manifolds may be designed for 1500 psig (10.35 MPa). Include cylinder bank headers with inlet (pigtail) connections complying with CGA V-1, individual inlet check valves, shutoff valve, pressure regulator, check valve, and pressure gage.
   c. Operation: Automatic, pressure-switch-activated changeover from one cylinder bank to the other when first bank becomes exhausted, without line-pressure fluctuation or resetting of regulators and without supply interruption by shutoff of either cylinder bank header.
   d. Medical Carbon Dioxide Manifolds: For 2 cylinders and 250-cfh (1.97-L/s) **OR** 4 cylinders and 500-cfh (3.94-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure.
   e. Medical Helium Manifolds: For 2 cylinders and 250-cfh (1.97-L/s) **OR** 4 cylinders and 500-cfh (3.94-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure.
   f. Medical Nitrous Oxide Manifolds: For 8 cylinders and 1333-cfh (10.5-L/s) **OR** 12 cylinders and 2000-cfh (15.7-L/s), **as directed**, capacity at 55-psig (380-kPa) line pressure, with electric heater or orifice design that will prevent freezing during high demand.
   g. Medical Nitrogen Manifolds: For 8 cylinders and 2000-cfh (15.7-L/s) **OR** 12 cylinders and 3000-cfh (23.6-L/s), **as directed**, capacity at 180-psig (1240-kPa) **OR** higher than 200-psig (1380-kPa), **as directed**, line pressure.
   h. Medical Oxygen Manifolds: For 12 cylinders and 1500-cfh (11.8-L/s) **OR** 20 cylinders 2500-cfh (19.7-L/s), **as directed**, capacity at 55-psig (380-kPa), **as directed**, line pressure.
   i. Medical Gas Cylinders: Will be furnished by Owner **OR** Number and type of medical gas cylinders required for complete manifold systems, **as directed**.
   j. Label manifold control unit with permanent label identifying medical gas type and system operating pressure.

k. Mounting: Wall with mounting brackets for manifold control cabinet and headers **OR** Floor with support legs for manifold control cabinet, **as directed**.

K. Bulk Gas Storage Tanks
1. Bulk Specialty Gas Storage Tanks:
2. Bulk Medical Gas Storage Tanks:
   a. Bulk Medical Gas Storage Tank Systems: Bulk storage tank with connections for alarm system, continuous supply, and reserve supply that will operate only during emergencies, complying with NFPA 99, "Health Care Facilities."
   b. Controls: Include actuating switch for alarm system connection and means for automatic actuating of reserve supply.
   c. Bulk Medical Gas Storage Tanks: Vertical mounting, double-wall construction with inner vessel fabricated according to ASME Boiler and Pressure Vessel Code for unfired pressure vessels and suitable for medical gas service. Include insulation and vacuum seal between walls. Fabricate outer shell from carbon steel with factory-applied manufacturer's standard protective paint finish suitable for exterior installation. Include the following features, specialties, and components:
      1) Safety Valves: ASME construction with pressure setting to correspond to tank working pressure and as required for component or system being protected.
      2) Pressure Gages: For tank pressure and facility service line pressure.
      3) Contents Gage: High- and low-level indicator with electric signal circuit connection.
      4) Drain Valves: For piping, inner vessel, and outer shell.
      5) Fill Assembly: Fill connection, piping, valves, relief devices, and controls.
      6) Facility Service Assembly: Piping, valves, relief devices, vaporizer, shutoff valve, pressure regulator, line shutoff valve or check valve, and reserve supply connection for connection to building service piping.
      7) Include permanent label showing medical gas type, storage tank capacity, tank pressure rating, vaporizer capacity, and operating instructions.
      8) Liquid Oxygen Storage Tank: Nickel-steel or stainless-steel inner vessel with 250-psig (1725-kPa) minimum working pressure. Include electric **OR** steam **OR** ambient vaporizer, **as directed**.
      9) Liquid Nitrous Oxide Storage Tank: Steel-alloy inner vessel with 300-psig (2070-kPa) minimum working pressure. Include electric **OR** steam, **as directed**, vaporizer.
   d. Oxygen Reserve Supply: Manifold header for high-pressure cylinders, fabricated from copper-tube or brass pipe and fittings and suitable for pressures up to 4000 psig (27.6 MPa). Include header inlet connections complying with CGA V-1, with individual inlet check valves, header shutoff valve, header pressure regulator, line shutoff valve or check valve, pressure gage, and inlet connections for number of cylinders indicated.
   e. Nitrous Oxide Reserve Supply: Manifold header for high-pressure cylinders, fabricated from copper-tube or brass pipe and fittings and suitable for pressures up to 4000 psig (27.6 MPa). Include header inlet connections complying with CGA V-1, with individual inlet check valves, header shutoff valve, header pressure regulator, line shutoff valve or check valve, pressure gage, inlet connections for number of cylinders indicated, and electric heater.

L. Medical Gas Piping Alarm Systems
1. Panels for medical gas piping systems may be combined in single panels with medical compressed-air and medical vacuum piping systems.
2. Components: Designed for continuous service and to operate on power supplied from 120 **OR** 240 **OR** 277, **as directed**,-V ac power source to alarm panels and with connections for low-voltage wiring to remote sensing devices. Include step-down transformers if required.
3. Pressure Switches or Pressure Transducer Sensors: Continuous line monitoring with electrical connections for alarm system.
   a. Low-Pressure Operating Range: 0- to 100-psig (0- to 690-kPa).
   b. High-Pressure Operating Range: Up to 250-psig (1725-kPa).

4. General Requirements for Medical Gas Alarm Panels: Factory wired with audible and color-coded visible signals to indicate specified functions.
   a. Mounting: Exposed, surface **OR** Recessed, **as directed**, installation.
   b. Enclosures: Fabricated from minimum 0.047-inch- (1.2-mm-) thick steel or minimum 0.05-inch- (1.27-mm-) thick aluminum, with knockouts for electrical and piping connections.
5. Master Alarm Panels: With separate trouble alarm signals, pressure gages, and indicators for medical gas piping systems.
   a. Include alarm signals when the following conditions exist:
      1) Medical Carbon Dioxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
      2) Medical Helium: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
      3) Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa) and changeover is made to alternate bank.
      4) Medical Nitrous Oxide (for bulk oxygen storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, and reserve level is low.
      5) Medical Nitrous Oxide (for nitrous oxide manifold system): Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
      6) Medical Oxygen (for bulk oxygen storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, reserve level is low, and reserve pressure is low.
      7) Medical Oxygen (for oxygen manifold system): Pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
6. Anesthetizing-Area Alarm Panels: Separate trouble alarm signals; pressure gages; and indicators for medical gas piping systems.
   a. Include alarm signals when the following conditions exist:
      1) Medical Carbon Dioxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
      2) Medical Helium: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
      3) Medical Nitrous Oxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
      4) Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa).
      5) Medical Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
7. Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
   a. Include alarm signals when the following conditions exist:
      1) Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
8. Dental Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
   a. Include alarm signals when the following conditions exist:
      1) Medical Nitrogen: Pressure drops below 145 psig (1000 kPa) or rises above 200 psig (1380 kPa) and changeover is made to alternate bank.
      2) Medical Nitrous Oxide (for bulk nitrous oxide storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, and reserve level is low.

3) Medical Nitrous Oxide (for nitrous oxide manifold system): Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.
4) Medical Oxygen (for bulk oxygen storage tank system with cylinder reserve): Liquid level is low, pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa), changeover is made to reserve, reserve is in use, reserve level is low, and reserve pressure is low.
5) Medical Oxygen (for nitrous oxide manifold system): Pressure downstream from main shutoff valve drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa) and changeover is made to alternate bank.

9. Medical Laboratory Area Alarm Panels: Separate trouble alarm signals; pressure and vacuum gages; and indicators for medical gas piping systems.
   a. Include alarm signals when the following conditions exist:
      1) Medical Carbon Dioxide: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
      2) Medical Helium: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).
      3) Medical Oxygen: Pressure drops below 40 psig (275 kPa) or rises above 60 psig (415 kPa).

M. Computer Interface Cabinet
1. Description: Wall-mounting, welded-steel, control cabinet with gasketed door, mounting brackets, grounding device, and white-enamel finish for connection of medical gas system alarms to facility computer. Include factory-installed signal circuit boards, power transformer, circuit breaker, wiring terminal board, and internal wiring capable of interfacing 20, **as directed**, alarm signals.

N. Gas Cylinder Storage Racks
1. Wall Storage Racks: Fabricate racks with chain restraints for upright cylinders as indicated or provide equivalent manufactured wall racks.
2. Freestanding Storage Racks: Fabricate racks as indicated or provide equivalent manufactured storage racks.

O. Sleeves
1. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
2. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

P. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Cast-Brass Escutcheons: With set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
   a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
7. One-Piece, Floor-Plate Escutcheons: Cast iron.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

Q. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
   a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
   c. Packaging: Premixed and factory packaged.

R. Nitrogen
1. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

1.3 EXECUTION

A. Earthwork
1. Comply with requirements in Division 02 Section "Earthwork" for excavating, trenching, and backfilling and for underground warning tapes.

B. Piping Applications
1. Nonhealthcare, Specialty Gas Piping: Type L, copper medical gas tube; wrought-copper fittings; and brazed **OR** press-type fittings and pressure-sealed, **as directed**, joints.
2. Nonhealthcare, Specialty Gas Piping NPS 2-1/2 (DN 65) and Smaller: Type K **OR** Type L, **as directed**, copper medical gas tube; wrought-copper fittings; and brazed **OR** press-type fittings and pressure-sealed, **as directed**, joints.
3. Nonhealthcare, Specialty Gas Piping NPS 3 (DN 80) and Larger: Type K, copper tube; wrought-copper fittings; and brazed **OR** press-type fittings and pressure-sealed, **as directed**, joints.
4. Medical Gas Piping: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
5. Medical Gas Piping Except Nitrogen: Use Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
6. Medical Nitrogen Piping: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
7. Medical Nitrogen Piping NPS 2-1/2 (DN 65) and Smaller: Type K **OR** Type L, **as directed**, copper medical gas tube; wrought-copper fittings; and brazed joints.
8. Medical Nitrogen Piping NPS 3 (DN 80) and Larger: Type K, copper tube; wrought-copper fittings; and brazed joints.
9. Protective Conduit: Use PVC pipe, PVC fittings, and solvent-cemented joints.

C. Piping Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of gas piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Comply with ASSE Standard #6010 for installation of medical gas piping.
3. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
6. Install piping adjacent to equipment and specialties to allow service and maintenance.
7. Install nipples, unions, and special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications below unless otherwise indicated.
8. Install piping to permit valve servicing.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.

11. Install medical gas piping to medical gas service connections specified in this Section, to medical gas service connections in equipment specified in this Section, and to equipment specified in other Sections requiring medical gas service.
12. Install exterior, buried medical gas piping in protective conduit fabricated with PVC pipe and fittings. Do not extend conduit through foundation wall.
13. Install seismic restraints on gas piping. Seismic-restraint devices are specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
14. Install medical gas service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
15. Connect gas piping to gas sources and to gas outlets and equipment requiring gas service.
16. Install unions, in copper tubing adjacent to each valve and at final connection to each piece of equipment and specialty.

D. Valve Installation
1. Install shutoff valve at each connection to gas laboratory and healthcare equipment and specialties.
2. Install check valves to maintain correct direction of gas flow from laboratory and healthcare gas supplies.
3. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
4. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
5. Install pressure regulators on gas piping where reduced pressure is required.
6. Install emergency oxygen connection with pressure relief valve and full-size discharge piping to outside, with check valve downstream from pressure relief valve and with ball valve and check valve in supply main from bulk oxygen storage tank.

E. Joint Construction
1. Ream ends of PVC pipes and remove burrs.
2. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
3. Threaded Joints: Apply appropriate tape to external pipe threads.
4. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter. Continuously purge joint with oil-free, dry nitrogen during brazing.
5. Pressure-Sealed Joints: Join copper tube and press-type fittings with tools recommended by fitting manufacturer.
6. Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of memory-metal coupling joints.
7. Solvent-Cemented Joints: Clean and dry joining surfaces. Join PVC pipe and fittings according to the following:
   a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
   b. Apply primer and join according to ASME B31.9 for solvent-cemented joints and to ASTM D 2672.

F. Gas Service Component Installation
1. Assemble patient service console with service connections. Install with supplies concealed, in walls. Attach console box or mounting bracket to substrate.
2. Install nitrogen pressure-control panels in walls. Attach to substrate.
3. Assemble ceiling columns and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.
4. Assemble ceiling assemblies and install anchored to substrate. Provide structural steel, hanger rods, anchors, and fasteners in addition to components furnished with specialties necessary to fabricate supports.
5. Install gas manifolds on concrete base, **as directed**, anchored to substrate.
6. Install gas cylinders and connect to manifold piping.

7. Install gas manifolds with seismic restraints as indicated.
8. Install bulk gas storage tanks and reserve supply tanks level on concrete bases. Set tanks and connect gas piping to tanks according to applicable requirements in NFPA 50 for bulk oxygen storage systems, **as directed**. Install tanks level and plumb, firmly anchored to concrete bases; maintain NFPA 50 and tank manufacturer's recommended clearances. Orient tanks so controls and devices are accessible for servicing.
9. Install bulk gas storage tanks and reserve supply tanks with seismic restraints.

G. Medical Gas Piping Alarm System Installation
1. Install medical gas alarm system components in locations required by and according to NFPA 99.
2. Install medical gas area and master alarm panels where indicated.
3. Install computer interface cabinet with connection to medical gas piping alarm system and facility computer.

H. Sleeve Installation
1. Sleeves are not required for core-drilled holes.
2. Permanent sleeves are not required for holes formed by removable PE sleeves.
3. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe **OR** galvanized-steel sheet **OR** stack sleeve fittings **OR** PVC pipe, **as directed**.
   a. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
   b. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

   OR

   Install sleeves in new walls and slabs as new walls and slabs are constructed.
4. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
      1) Seal space outside of sleeve fittings with grout.
5. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

I. Escutcheon Installation
1. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
   a. New Piping:
      1) Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
      2) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** stamped steel with set screw **OR** stamped steel with set screw or spring clips **OR** stamped steel with spring clips, **as directed**.
      3) Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish **OR** One piece or split casting, cast brass with polished chrome-plated finish **OR** Split casting, cast brass with polished chrome-plated finish **OR** One piece, stamped steel with set screw **OR** One piece or split plate, stamped steel with set screw **OR** Split plate, stamped steel with set screw, **as directed**.

4) Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish **OR** cast brass with rough-brass finish **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
5) Bare Piping in Equipment Rooms: One piece, cast brass **OR** stamped steel with set screw **OR** stamped steel with spring clips **OR** stamped steel with set screw or spring clips, **as directed**.
6) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

b. Existing Piping:
1) Chrome-Plated Piping: Split casting, cast brass with chrome-plated finish.
2) Insulated Piping: Split plate, stamped steel with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
3) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and spring clips, **as directed**.
4) Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish **OR** plate, stamped steel with concealed hinge and set screw, **as directed**.
5) Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish **OR** casting, cast brass with rough-brass finish **OR** plate, stamped steel with concealed hinge and set screw or spring clips **OR** plate, stamped steel with concealed or exposed-rivet hinge and set screw or spring clips **OR** plate, stamped steel with exposed-rivet hinge and set screw or spring clips, **as directed**.
6) Bare Piping in Equipment Rooms: Split casting, cast brass **OR** plate, stamped steel with set screw or spring clips, **as directed**.
7) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

J. Hanger And Support Installation
1. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
2. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices.
3. Vertical Piping: MSS Type 8 or 42, clamps.
4. Individual, Straight, Horizontal Piping Runs:
a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel, clevis hangers.
b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable, roller hangers.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for trapeze hangers.
6. Base of Vertical Piping: MSS Type 52, spring hangers.
7. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
8. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
9. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
a. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
b. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
c. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
d. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
e. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
f. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
g. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
h. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
i. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
j. NPS 3-1/2 (DN 90): 15 feet (4.6 m) with 1/2-inch (13-mm) rod.

k. NPS 4 (DN 100): 16 feet (4.9 m) with 1/2-inch (13-mm) rod.
l. NPS 5 (DN 125): 18 feet (5.5 m) with 1/2-inch (13-mm) rod.
m. NPS 6 (DN 150): 20 feet (6 m) with 5/8-inch (16-mm) rod.
n. NPS 8 (DN 200): 23 feet (7 m) with 3/4-inch (19-mm) rod.

10. Install supports for vertical copper tubing every 10 feet (3 m).

K. Labeling And Identification

1. Install identifying labels and devices for specialty gas piping, valves, and specialties. Comply with requirements in Division 15 Section "Identification For Plumbing Piping And Equipment".
2. Install identifying labels and devices for healthcare medical gas piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
   a. Carbon Dioxide: Black or white letters on gray background.
   b. Helium: White letters on brown background.
   c. Nitrogen: White letters on black background.
   d. Nitrous Oxide: White letters on blue background.
   e. Oxygen: White letters on green background or green letters on white background.

L. Field Quality Control For Laboratory Facility Specialty Gas

1. Perform field tests and inspections of specialty gas piping for nonhealthcare laboratory facilities and prepare test reports.
2. Tests and Inspections:
   a. Piping Leak Tests for Specialty Gas Piping: Test new and modified parts of existing piping. Cap and fill specialty gas piping with oil-free, dry nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
   b. Repair leaks and retest until no leaks exist.
   c. Inspect specialty gas regulators for proper operation.

M. Field Quality Control For Healthcare Facility Medical Gas

1. Perform tests and inspections of medical gas piping systems in healthcare facilities and prepare test reports.
2. Tests and Inspections:
   a. Medical Gas Piping Testing Coordination: Perform tests, inspections, verifications, and certification of medical gas piping systems concurrently with tests, inspections, and certification of medical compressed-air piping and medical vacuum piping systems.
   b. Preparation: Perform the following Installer tests according to requirements in NFPA 99 and ASSE Standard #6010:
      1) Initial blow down.
      2) Initial pressure test.
      3) Cross-connection test.
      4) Piping purge test.
      5) Standing pressure test for positive pressure medical gas piping.
      6) Standing pressure test for vacuum systems.
      7) Repair leaks and retest until no leaks exist.
   c. System Verification: Comply with requirements in NFPA 99, ASSE Standard #6020, and ASSE Standard #6030 for verification of medical gas piping systems and perform the following tests and inspections:
      1) Standing pressure test.
      2) Individual-pressurization **OR** Pressure-differential, **as directed**, cross-connection test.
      3) Valve test.
      4) Master and area alarm tests.
      5) Piping purge test.

6) Piping particulate test.
7) Piping purity test.
8) Final tie-in test.
9) Operational pressure test.
10) Medical gas concentration test.
11) Medical air purity test.
12) Verify correct labeling of equipment and components.
13) Verify the following source equipment:
    a) Medical gas supply sources.

d. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
    1) Inspections performed.
    2) Procedures, materials, and gases used.
    3) Test methods used.
    4) Results of tests.

3. Remove and replace components that do not pass tests and inspections and retest as specified above.

END OF SECTION 15063b

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Task	Specification	Specification Description
15063	15061	Common Work Results for Fire Suppression
15063	15061a	Common Work Results for Plumbing
15063	15061b	Common Work Results for HVAC
15063	15061c	Domestic Water Piping
15063	15061d	Sanitary Waste And Vent Piping
15063	15061e	Storm Drainage Piping
15063	15061f	Hydronic Piping
15063	15061h	Refrigerant Piping
15063	15061j	General-Service Compressed-Air Piping

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SECTION 15064 - RELIEF WELLS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for relief wells. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Shop Drawings: Submit shop drawings.
2. Statements
   a. Before installation, all well screen shall be approved.
   b. The filter pack material and its gradation shall be approved before it is placed.
   c. Submit the cement grout mixture proportion to be used in plugging abandoned wells.
3. Reports: Submit sampling and testing reports for each relief well, logs of the borings, well screen and riser pipe, backfill material, and pump tests. Register each well with the state as required by the state in which the well is installed.

C. Regulatory Requirements: The state statutory and regulatory requirements form a part of this specification.

1.2 PRODUCTS

A. Well Screen: The Contractor may, at his option, furnish and install well screen of any of the alternate types specified. The clear inside diameter of the screen shall be as directed by the Owner. Screen openings shall be uniform in size and pattern, and shall be spaced approximately equally around the circumference of the pipe.
1. PVC Pipe Screen: Pipe, fittings, and screen shall be of the size and types specified. Pipe, fittings, and screen shall conform to ASTM D 1784, ASTM D 1785, ASTM D 2466, or ASTM D 2467. All joints in the PVC pipe shall include couplings and shall be glued with a solvent cement conforming to ASTM D 2564. The PVC pipe strength properties shall be equivalent to PVC 1120 Schedule 40 **OR** 80, **as directed**, unthreaded plastic pipe.
   a. Couplings: Couplings shall be bonded socket **OR** threaded, **OR** certilock, **as directed**, type. Fittings shall be produced of the same material and equal quality as specified for plastic pipe screen. Socket type fitting connections of pipe sections shall be bonded with solvent cement. The determination of the proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall be the responsibility of the Contractor. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the solvent cement. Self-tapping screws or other devices for holding pipe in the couplings during the setting period may be utilized as long as the screws do not penetrate the inside of the pipe. In no case shall a newly-made joint in the casing be stressed, lowered into the relief well, or be submerged in water prior to complete curing of the solvent cement adhesive.
   b. Perforations: The PVC well screen shall be mill slot **OR** continuous wire wrapped rod base **OR** continuous wire wrapped rod base on perforated pipe **OR** continuous wire wrapped on perforated pipe screen **OR** similar to that manufactured by Johnson Well Equipment, Inc., Pensacola, FL, telephone (904) 453-3131, **as directed**. All well screen shall have smooth, sharp-edged openings free of burns, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.

2. Fiberglass Pipe Screen: Fiberglass pipe screen and fittings shall be manufactured from thermosetting epoxy resins and glass fiber by either a centrifugal casting process or by a filament winding process. Glass fiber used shall be continuous filament, electrical glass with a finish compatible with epoxy resins. Each glass fiber or filament shall be thoroughly impregnated with epoxy resin. Fiberglass pipe wall thickness, strength and durability requirements shall be equivalent to the Fiberglass/Epoxy pipe produced by Fiberglass Resources Corporation of Farmingdale, New York or Burgess Well Company, Inc., Minden, Nebraska, telephone (308) 832-1642. All fiberglass pipe and fittings shall be round and straight, of uniform quality and workmanship, and free from all defects including indentation, delamination, bends, cracks, blisters, porosity, dry spots, resin segregation and resin-starved areas. The inside of the pipe and fittings shall be smooth and uniform. The impregnation of the glass fiber with resin shall be such that when the pipe is cut or slotted, no fraying or looseness of glass fiber occurs.
   a. Couplings: Couplings for fiberglass pipe sections shall be socket threaded or mechanical key-type couplings. The couplings shall be manufactured of the same materials used for the fiberglass pipe specified herein and may be either cast integrally with the pipe sections or as separate components for attachment to the pipe in the manufacturers plant. Key-type couplings shall consist of male and female halves designed for joining and locking together by means of a key strip inserted in grooves in the coupling halves. The minimum wall thickness remaining at any grooved section shall not be less than the minimum thickness specified for pipe. Key strips and locking strips shall be of fiberglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the design load for the coupling. Socket type fitting connections of the pipe sections shall be bonded with epoxy adhesive. The epoxy materials and bonding agents shall be as recommended by the pipe manufacturer. Self-tapping screws or other devices for holding adhesive-joined pipe in the couplings during the curing period may be utilized. In no case shall a newly-made joint in the casing pipe be lowered into the relief well, or be submerged in water prior to complete curing of the adhesive.
   b. Perforations: All fiberglass well screen shall be mill slot **OR** continuous wire wrapped rod base, **as directed**. All relief well screen shall have smooth, sharp-edged openings free of burrs, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.
3. Steel Pipe Screen: Steel well screen shall consist of perforated or slotted sections of steel pipe conforming to the requirements of ASTM A 53.
   a. Couplings: Couplings for steel pipe screen shall be welded joints or threaded couplings. Welding shall be performed in accordance with requirements in ASME B31.9. Couplings shall meet the material requirements specified for steel pipe screen, except perforations shall be omitted. All threaded pipe and fittings shall be threaded in accordance with ASME B1.20.1. All threaded pipe sections may be field connected. Couplings shall be given the same protection against corrosion as specified for the well screen pipe. Protective coatings damaged while making couplings shall have the areas recoated.
   b. Perforations: All steel pipe to be used as relief well screen shall be provided with perforations which shall consist of either machine-cut slots; drilled or punched openings. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe. The pattern of the openings shall be uniformly spaced around the periphery of the pipe.
4. Stainless Steel Well Screen: The perforated well screen and fittings shall be fabricated entirely from stainless steel conforming to ASTM A 312/A 312M, Type 304, 304-L, 316 or 316-L. The well screen shall be of stainless steel with a keystone wire-wrapped continuous slot strainer equivalent to that manufactured by Howard Smith Screen Company, Houston, TX, telephone (713) 869-5771 or Johnson Screens, St. Paul, MN 55164, telephone (612) 636-3900.
   a. Couplings: Couplings for the stainless steel well screen shall consist of the same material as the well screen and shall be threaded, flanged, and/or fitted with a welding ring. The

couplings shall conform in design to the couplings recommended by the manufacturer of the well screen.

b. Tailpipe for Well Screen: The tailpipe for each well screen shall be made of the same material and at least the same minimum thickness as the riser pipe and shall include a bottom plug.

B. Riser Pipe: The relief well riser pipe material and method of manufacture shall conform to the requirements specified in paragraph WELL SCREEN, except that the screen perforations or opening shall be omitted. The relief well riser pipe diameter and discharge details shall be as directed. Couplings to the well screen and between riser pipe sections shall be as specified in paragraph COUPLING.

C. Filter Pack: Material for the filter pack around the riser pipes and screens shall be a washed grave, **OR** washed sand **OR** dry processed sand, **as directed**, composed of hard, tough, and durable particles free from adherent coating. The filter pack shall not be crushed stone. The filter pack material shall contain no detrimental quantities of organic matter nor soft, friable, thin, or elongated particles in accordance with the quality requirements in ASTM C 33, Table 1 and Table 3, Class 5S, and in ASTM E 11, Table 1.

D. Outlet For Relief Well: Check Valve.

1. The check valve shall be a one piece reinforced all rubber (neoprene) check valve with an integral elastomer flange similar and equal to the Red Valve Series 35, manufactured by Red Valve Company, Inc., 700 North Bell Ave., Pittsburgh, PA 15106, telephone (412) 279-0044. The backup ring for the check valve shall be stainless steel. Stainless steel bolts, washers, and nuts shall be used to fasten the valves onto the flanged end of the pipes. The check valve shall be installed with the flared end duck bill in a vertical position.
OR
Fabricate check valves of brass **OR** stainless steel **OR** aluminum, **as directed**, plate, threaded fasteners and rods. Fabricate sealing disc of silicone sponge rubber free of porous areas, foreign materials, and visible defects.
2. Workmanship and metalwork fabrication of check valves shall be as directed. Install check valves accurately vertically and adjust to the required elevation.

E. Concrete: Concrete shall conform to the requirements specified in Division 03 Section "Cast-in-place Concrete".

1.3 EXECUTION

A. Drilling: Wells may be drilled by the reverse rotary circulation method or other method approved, which will ensure proper placement of the well screen, riser pipe, and filter pack. Methods which involve radical displacement of the formation, or which may reduce the yield of the well, will not be permitted. Excavated material shall be disposed of as directed.

1. Reverse Circulation Method: If the reverse circulation method is used for drilling wells, all of the drilling fluid shall be removed from the filter pack and the natural pervious formation. If in the opinion of the Owner the walls of the hole above the top of the filter pack require support during development operations, a temporary casing similar to that specified in paragraph TEMPORARY CASING shall be placed so as to extend from the ground surface to at least 3 ft (1 m) below the top of the filter pack. The diameter of the hole shall be such as will permit the placement of the minimum thickness of filter pack as specified in paragraph FILTER PACK PLACEMENT. The drilling fluid shall be a suspension of fine grained soil or shall be a commercial product of a recognized manufacturer, shall be approved by the Owner, and shall have the characteristic of being readily removable from the filter pack and the walls of the formation by development as specified in paragraph DEVELOPMENT. The use of bentonite will not be permitted.
2. Temporary Casing: Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. the Owner will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and

filter pack when he believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth 3 ft (3 m) below the top of the filter pack. The temporary casing, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it shall be discarded and a new casing shall be used during installation of any additional relief wells.

B. Installation Of Riser Pipe And Screen

1. Assembly: All riser pipe and screen shall be in good condition before installation and all couplings and other accessory parts shall be securely fastened in place. The successive lengths of pipe shall be arranged to provide accurate placement of the screen sections in the bore hole. The riser-pipe shall be provided with an approved cap and a flanged top section, the top of which shall be set at the elevation directed. Centralizers shall be attached to the assembled riser pipe and screen in such numbers and of a type that they will satisfactorily center the riser pipe and screen in the well and will hold it securely in position while the filter pack material is being placed.
2. Joints: Sections of relief well pipe shall be joined together as specified in paragraph COUPLINGS. Joints shall be designed and constructed to have the strength of the pipe and where possible a strength capable to support the weight of the relief well stem as it is lowered into the hole. When not practicable to construct joints that will support the weight of the relief well stem, the stem shall be supported at the lower end by any approved means that will assure that the joints do not open while being lowered into place in the well.
3. Installation: The assembled riser pipe and screen shall be placed in the bore hole in such manner as to avoid jarring impacts and to ensure that the assembly is centered and not damaged or disconnected. The screen shall be suspended in the hole and not resting on the bottom of the hole. After the screen and riser pipe have been placed, a filter pack shall be constructed around the screen section as specified in paragraph FILTER PACK PLACEMENT and the well developed as specified in paragraph DEVELOPMENT. The top of the riser pipe shall be held at the designated elevation during placement of the filter pack.
4. Check for Plumbness and Alignment: The well shall be constructed and all casing set round, plumb, and true. The Contractor shall perform the following tests after the installation of the well but prior to backfilling, and before its acceptance. Additional tests may be made during the performance of the work at the option of the Contractor. Should the Contractor fail to correct, at no additional cost to the Owner, any faulty alignment or plumbness disclosed as a result of these tests, the Owner may refuse to accept the well. the Owner may waive the requirements for plumbness if in his judgement the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond his control or if the utility of the completed well is not materially affected or if the cost of necessary remedial measures will be excessive. In no event will the provisions with respect to alignment be waived.
    a. Plumbness: Plumbness shall be tested by use of a plumb line. The plummet shall be suspended from a small diameter wire rope and its point of suspension shall be in the exact center of the plummet. The plummet shall be sufficiently heavy to stretch the wire rope taut. The wire rope shall pass over a guide sheave which shall be positioned above the top of the well and adjusted horizontally so that the plummet hangs in the center of the well. Displacement of the wire rope during the plumbness check shall be measured by means of a transparent plastic sheet on which a number of concentric circles shall be scribed or drawn, and which is centered on the top of the well. The exact center of these circles shall be marked, and then a slot, slightly larger than the plumb line and extending from this center to the edge, shall be cut in the plastic sheet. As the plummet is lowered, any out-of-plumb condition of the well will be indicated by the wire rope tending to drift away from the center, and the plastic sheet shall be rotated until the slot is oriented in the direction of this drift, while at all times maintaining the center of the concentric circles coincident with the center of the well. Measurement of the amount of drift shall be made

along the edge of the slot for each increment by which the plummet is lowered into the well. Drift at any depth shall be determined by multiplying the measured plumb line displacement by the total length of the plumb line and dividing the result by the fixed distance between the guide sheave and the top of the well. If desired, alignment may be calculated from the plumbness data in lieu of the alignment check described in paragraph ALIGNMENT. Should the well vary from the vertical in excess of allowable, the plumbness of the well shall be corrected by the Contractor at no additional cost to the Owner.

b. Alignment: Alignment shall be tested by lowering into the well a section of cylinder or a dummy of the same length. The outside diameter of cylinder shall be smaller than the inside diameter of the well. Should the cylinder fail to move freely throughout the length of the well, the alignment of the well shall be corrected by the Contractor at no additional expense to the Owner.

C. Filter Pack Placement: After the well screen and riser pipe have been installed, the filter pack material shall be placed by tremie, when using a well graded material, in an approved manner such that segregation will not occur. When using a uniform graded filter material, the material may be poured around the well screen at a rate that will prevent bridging of the material. The material shall be placed around all sides of the screen to assure that the screen is not pushed against the side of the bore hole causing the screen to come in contact with foundation material or prevent the proper thickness of filter from being placed uniformly around the screen. The filter pack shall be placed at a constant rate from the start of placement until it has reached the elevation directed. If a tremie is required, a double string of tremie pipe shall be used. The pipes shall be placed on opposite sides of the screen and/or casing, that is, 180 degrees apart, and shall be guided in such a manner that they will remain in this position throughout the placing process. The tremie pipes shall be set in place, filled completely with filter pack prior to being lifted off the bottom of the hole. The filter pack in the tremie pipe shall be kept above the water surface in the well throughout the placing process. In no case shall the gradation of the filter pack fall outside of the range specified in paragraph FILTER PACK.

D. Development

1. General: Following placement of filter pack materials, the Contractor shall develop the relief well by jetting, surging, intermittent pumping, or other approved methods as may be necessary to give the maximum yield of water. At the time of development of any relief well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor shall be responsible for maintaining at the relief well the needed access and work area and clearance in the relief well necessary to accomplish development. The Contractor shall furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge a sufficient distance from the work areas to prevent damage. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. As development proceeds, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If at any time during the development process it becomes apparent in the opinion of the Owner that the well may be damaged, development operations shall be immediately terminated. the Owner may require a change in method if the method selected does not accomplish the desired results. the Owner may order that wells which continue to produce excessive amounts of fines after development for 6 hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.

a. Jetting: Jetting should be performed using either a single or double ring jet. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have two hydraulically balanced nozzles spaced 180 degrees **OR** four diameter holes spaced 90 degrees, **as directed**, apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within 1/2 in. (13 mm) from the inner surface of the well screen. The pump used in conjunction with

the jetting tool shall be capable of providing a minimum jetting fluid exit velocity of 150 feet per second (45 meters per second). Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. All wells shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. the Owner may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

b. Intermittent Pumping: Intermittent pumping shall be performed by pumping the well at a capacity sufficient to produce a rapid drawdown, stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Owner, the efficiency of the well might otherwise be impaired.

c. Surging: Surging of the well shall require use of a circular block which is smaller in diameter than the inside diameter of the relief well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately one hour or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. All materials pulled into the well by the surging process shall be removed by the Contractor.

E. Backfilling: After the well has been developed, additional filter pack shall be added if necessary to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the annular space above the filter pack, shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with grout or concrete. The concrete backfill shall be placed to a depth at least equal to the existing impervious blanket. For PVC riser pipe, after the well has been developed, additional filter pack shall be added if necessary for it to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the remaining annular space above the filter pack shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with bentonite. The temporary casing, if used, shall be withdrawn in increments as the backfill is placed. The Contractor shall fill with impervious material to original grade all pits such as those incidental to the reverse rotary circulation method of drilling.

F. Plugging Of Abandoned Wells: The Contractor has the option of attempting to remove the well screen. If the well screen can be removed, the Contractor will grout the bore hole starting from the bottom of the hole. The grouting shall start at the elevation of the bottom of the tailpipe of the well. If the well screen can not be removed or breaks off during the removal attempt, the Contractor shall still be responsible for grouting the well from the bottom of the tailpipe to within 3 ft (1 m) of ground surface. Either of the above abandonment procedures may require the Contractor to redrill the hole so that the bore hole can be grouted. The well shall be grouted from the bottom of the tailpipe. After the grout has setup the riser pipe shall be cutoff. Then the hole shall be backfilled. The cement grout mixture proportion to be used shall be submitted for approval.

G. Tests

1. Pump Test: Upon completion but before acceptance, each well shall be subjected to a pump test of which a sand test will form a part. The Contractor shall provide a deep well turbine pump, capable of producing the specified drawdowns over periods of time sufficient to satisfactorily perform the pump test specified herein. The intake shall be set below the maximum expected drawdown in the well. The amount of sand shall be measured after each test. The pump shall be complete with either gasoline, diesel, or electric motor of adequate size. In case an electric motor is used, the Contractor shall provide, without additional cost to the Owner, the electric power and the necessary wiring. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well. The Contractor shall furnish and install an orifice meter of approved design or other approved equipment for the purpose of measuring the discharge from the well during the pumping test. The Contractor shall furnish, install, or construct the necessary pipe discharge line, troughs, or ditches necessary to dispose of the pumping test discharge a sufficient distance from the work area to prevent damage. The tests will be conducted under the direction of the Owner and may be made as soon as each well is completed. Test data will be recorded by the Owner. The Contractor shall test each well by pumping continuously for a minimum of 6 hours. Prior to starting the pump test all material shall be removed from the bottom of the well. If the test is interrupted, other than by order of the Owner, prior to the completion of the specified period of continuous operation, the test shall be re-run. In addition to the required pumping test, the Owner may direct the Contractor to perform additional pump tests. Such additional testing shall conform in general to the requirements specified herein except that the duration of the tests and the approximate draw-down will be determined by the Owner. In the event that sand or other material collects in the well as a result of the pump test, accurate measurements shall be taken as to the quantity of material in the well and all such material shall be removed by the Contractor. Upon completion of the pump test, the Contractor shall remove all equipment, discharge lines, electrical lines, lumber, and debris, and shall backfill any excavated areas with impervious material.
2. Sand Test: As part of each Pump Test or at the end of each intermittent pumping a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. After the pump is at the desired pumping rate the flow from the discharge shall be diverted into a container that will collect all the sand being carried by the water **OR** through a Rossum Sand Tester, **as directed**. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.
3. Filter Pack Sampling and Testing: The Contractor shall verify that all materials conform to the specifications before delivery to the project. The particle size distribution of the filter pack shall be sampled and tested by the Contractor in accordance with ASTM C 136 and ASTM D 75. Within 48 hours before being placed in the relief well to be back-filled, the filter pack shall be sampled from the material stockpiled at the project site. There shall be at least one particle size distribution test on the filter pack for each well. A pump test shall be performed in accordance with technical provisions herein specified.
4. Reports: Reports shall include, for each relief well, logs of the boring, elevations of the well screen, top of riser pipe, bottom of the tailpipe, filter pack gradation, quantity of filter pack added during development, pump test, sand test, and report of backfilling. The log of backfill material shall include the filter pack particle size distribution test data, and notes concerning installation and development of the relief well. The pump test log shall include the duration of the test and the draw-down response data with time in the pumped well, in adjacent wells, and in nearby piezometers. The relief well log and the pump test log shall be submitted to the Owner. The Contractor shall also submit a report of the well installation to the appropriate public agency and in the form required by state statutory and/or regulatory requirements specified in paragraph REGULATORY REQUIREMENTS.

END OF SECTION 15064

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SECTION 15064a - UNDERGROUND STORAGE TANKS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of underground storage tanks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Intent of Work
1. It is the intent of this specification to ensure that the work, as completed, shall meet or exceed all applicable codes, ordinances, rules and regulations of every authority having jurisdiction in the area.
2. The installation shall include all necessary equipment, controls, valves and fittings, excavation, backfill as described or called for on the plans. In some cases, the Contractor shall prepare the plans. In any case, the Contractor shall obtain all permits at his expense.
3. The Contractor shall install equipment in accordance with manufacturer's recommendations. Where drawings (if any) and specification conflict with manufacturer's recommendations, it shall be the Contractor's responsibility to bring this to the attention of the Owner before installation.
4. The overall intent shall be that the Contractor shall provide everything required to make a complete and operational job in every respect.

C. Codes And Standards
1. Reference is to the latest edition of the code or standard unless otherwise noted. Comply with the latest EPA requirements.
2. The codes and standards referred to are the minimum standards. Where the requirements of these specifications and the accompanying drawings (if any) exceed those of the codes and standards, the drawings and specifications shall supersede.
3. The installation shall conform to provisions of the NFPA requirement with latest amendments.
4. The entire installation including all equipment shall conform to The Occupational and Safety Health Act of 1970, and all EPA regulations.

D. Visit To Site: Bidders are advised to visit the site and carefully examine the existing conditions before submitting bids, as no allowance will be made for lack of knowledge of existing conditions where such conditions may reasonably be determined by observation.

E. Permits
1. Obtain all permits required for the installation of this work and pay all fees in connection therewith. Permits and fees involved in removal of any item from the site shall be included.
2. Provide copies of inspection and testing certificates from all agencies and authorities having jurisdiction.

F. Layout Basis
1. The layout, which must be stamped by an Engineer registered in the State in which the Project is located, is based upon the use of particular items of equipment, identified by manufacturer's make and model number. Dimensions, arrangements, efficiency and service connections required for these particular items have been considered in making the layout. Contractor shall submit any deviations proposed with his bid.
2. The Contractor may use the equipment of any manufacturer listed as approved for substitution provided they have the proper connections, capacities, efficiency and dimensions. Variances from the requirements stated herein shall be sustainable reasons for disapproval of the submitted equipment. All costs arising from variances in substituted items shall be paid for by the Contractor.

3. Equivalent products by other manufacturers must be submitted to the the Owner for prior approval at least ten (10) days prior to bid date.

G. Submittals
1. All submittals shall bear a stamp or notation indicating that the Contractor has reviewed the submittals for compliance with drawings, governing authorities and specifications.
2. All submittals shall bear sufficient notations to clearly indicate the specific make, model number, accessories, capacities, options, and specification paragraph numbers.
3. All submittals shall indicate complete compliance with all performance and specification requirements as herein specified and/or indicated or shall specifically list any exceptions. Exceptions shall be subject to approval by the the Owner.
4. The review (by the the Owner) of equipment does not relieve the Contractor of the responsibility for compliance with the contract documents or authorities as specified.
5. Contractor shall coordinate electrical characteristics of equipment with electrical specifications and the available power characteristics.
6. Materials requiring shop drawing submittals shall not be installed prior to shop drawings being reviewed by the the Owner. The Contractor agrees that failure to conform to the above may result in removal of all installed materials that have been disapproved from the project. Installation of specified equipment will be mandatory. Removal of disapproved equipment shall be at the sole expense of the Contractor.
7. Submit the following for review via shop drawings (to be approved or disapproved):
   a. Xerxes or approved equal, double wall (do not unload manually). Size and capacity.
   b. Bury depth.
   c. Bed and backfill (not over 7'-0" traffic and no traffic).
   d. Double walls when continuous vacuum pump and monitor are used require a maximum burial depth of three (3) feet from tank top to grade.
   e. When not subjected to traffic loads, use 24" backfill or 12" minimum backfill plus 4" re-bar reinforced concrete on top.
   f. When subjected to traffic loads, use 36" backfill or 18" minimum backfill plus 6" of re-bar reinforced concrete.
   g. If tank is 12'-0" in diameter (actually, 7'-11" is manufactured for large gallonage) then, no traffic shall be provided with 42" minimum cover, or 38" backfill plus 4" re-bar reinforced concrete. With traffic, use 38" backfill plus 6" of asphalt or 6" of re-bar reinforced concrete.
   h. Monitoring fittings, fiberglass reservoir, vapor sensor 4" tank fittings, tank fill tube insert, venting, stage two vapor recovery system, manway and manway extensions, manway risers, site monitoring wells, barricades, installation check list, hydrostatic tank monitoring.
   i. Job site safety precautions.
   j. Reservoir fiberglass sensor.
   k. Reservoir leak detection.
   l. Electronic control panels, sensor circuit, transmission contact switch power source circuit, alarm bell, alarm bell silence button, control panel false alarms, etc.
   m. Piping sump bottom, usually 28 3/8" x 30".
   n. Flex connectors to piping.
   o. Unions, nipples, manway cover, FRP fitting, opening for stage II vapor recovery line if required.
   p. 3" pipe sump fitting.
   q. When using piping sump sensor equal to Owens Corning fiberglass model PSS, submit system including electrical power supply and signal wiring.
   r. Control panel equal to Owens Corning fiberglass model SB-0011B (single circuit) or SB-0014B (4 circuit) as applicable.
   s. Fiberglass pipe and fittings equal to "Ameron" type Dualoy 3000/L pressure rated and with chemically resistant epoxy resin for the service intended. The Dualoy 3000/L shall be a secondary containment system. No other product piping will be acceptable.

H. Guarantee

1. Contractor shall guarantee that if any materials or workmanship covered by these specifications proves defective within one (1) year, such defects shall be corrected by the Contractor at once without charge to the Owner.

1.2 PRODUCTS:

A. Double-Wall Fiberglass Underground Storage Tanks

1. The Contractor shall provide and install the "fiberglass" underground storage tanks of the specified volume and diameter.
2. The tank shall be of fiberglass. Tank laminates shall be constructed of 100% resin and fiberglass reinforcements without sand fillers. Ribs are to be integrally cast into tank body. Tanks shall bear the listing mark of Underwriters' Laboratories, Inc. Tank shall have an annular space between the primary and secondary shell walls to allow for free flow and containment of all leaked product from primary tank. This space shall be filled at the factory with a brine solution for hydrostatic monitoring. Tanks shall be as manufactured by Xerxes Corporation, Minneapolis, MN or approved equal as judged by the Owner.
3. The tank shall comply with the following governing standards:
   a. ASTM Standard Document No. 4021-81
   b. Underwriters' Laboratories, Inc. (UL.) File #MH-9061 (N) for underground storage of flammable liquids. A UL certification plate shall be attached to each tank.
   c. Military Specification No. MIL-T-52777(A)
   d. Factory Mutual Systems approval J.I. IG4AO.AF
   e. National Sanitation Foundation, Standard 14
   f. National Fire Protection Association (NFPA-30), (NFPA-30A) Flammable and Combustible Liquid Code and (NFPA-31) Standard for Installation of Oil Burning Equipment.
4. The tank shall be capable of the following loading conditions:
   a. Internal load: Tank shall withstand 5 psi air pressure test with 5 to 1 safety factor. Contractor shall test prior to installation as this is to test for leakage. Maximum test pressure is 5 psi.
   b. Vacuum Test: Every tank shall be tested to 11.5 inches (primary tank) and 9.5 inches (secondary tank) mercury vacuum by the tank manufacturer to assure structural integrity.
   c. Surface Loads: Tank shall withstand surface H-20 axle load when properly installed according to current manufacturer's installation instruction (32,000 lbs.).
   d. External hydrostatic pressure: Tank shall withstand 7' of overburden with the hole fully flooded with 7:1 safety factor against buckling.
5. Provide glass fiber-reinforced plastic straps for the tank shown. Provide number and location of straps as specified by the manufacturer. Each strap shall be capable of withstanding the buoyancy load of 25,000 lbs. for 8' tank diameter. Straps shall be standard as supplied by the tank manufacturer. A concrete pad or concrete deadman must be used with anchor straps as recommended by tank manufacturer.
6. The Contractor shall provide fiberglass piping sump with fittings as indicated. The piping sump shall be manufactured by Xerxes Corporation or approved equal and supplied with tanks.
   a. The piping sump shall be installed so that it is suitable for monitoring the double-wall piping system and containment of its product. Piping sump shall be located on tanks 22" minimum manway.
7. All tank fittings shall be standard (proofed tight) as supplied by the tank manufacturer. The tank shall have an opening for one each of the following:
   a. Fill/Manual Gauging
   b. Vent/Overfill/Stage One Vapor Recovery
   c. Pump (pressure system) or supply and return (suction system)
   d. In tank gauging automatic inventory control
   e. Others as shown or required by the operating agency
8. The tank shall have a factory filled brine interstitial and reservoir for continuous monitoring of both inner and outer walls.

9. Tank to be installed per manufacturer installation instructions which will be inspected as it progresses.

B. Spill Protection
1. Universal model 70CD, or approved equal, spill containment shall be used as containment basin for spills during filling. A manual valve, if so required, shall be used to return any spilled product back to tank.

C. Overfill Prevention
1. Universal model 37, or approved equal, float valve is to be used for overfill prevention. The automatic shut off device must stop the flow of product being delivered when tank is 90% full. Access must be provided.

D. Stage One Vapor Recovery
1. Stage one vapor recovery is incorporated into the access assembly of the overfill prevention access way. See drawing for details. (Less than 10,000 gales per month through flow)

E. Stage Two Vapor Recover
1. Piping for stage two vapor recovery will be installed for future use. Required for gasoline motor fuel only. (More than 10,000 gales per month through flow)

F. Tank Trim
1. Surface manholes shall have all cast iron rim and minimum 10" galvanized steel skirt. Tank trim shall have Universal Valve.

G. Submersible Turbine Pump Specifications
1. General Pump Specifications: The pump shall be designed to pump gasoline, diesel, kerosene and jet fuel. The entire pumping assembly shall have UL listing and shall meet all requirements of UL79. The pump discharge head and manifold assembly shall be manufactured from ASTM A 48 Class 30 grey iron. The pump shall be available in 1/3, 3/4, and 1-1/2 hp sizes and shall be manufactured to the proper length as determined by the tank diameter, type of tank, and bury depth. The pump motor shall have a thermal over current overload protector with automatic reset. The pump motor assembly shall be clearly marked with pertinent information including Model, Horsepower, Voltage, Phase, and Manufacturer. The pump motor shall be a permanent split phase capacitor type, and shall incorporate a 15 mfd capacitor. The pumping unit shall not incorporate any flexible diaphragms and all sealing shall be accomplished with "o" ring or UL recognized fiber gaskets. The pump shall have a removable intake screen with openings no greater than 3/32 inch. The pump shall be manufactured by FE Petro, Inc., McFarland, WI. or approved equal as judged by the the Owner.
2. Installation and Maintenance Specifications: The pump shall have a two-wire field connection and an easy access ground wire terminal, and shall incorporate a wire seal plug which will accommodate three wires. The pump shall incorporate a port for line pressure testing that shall be sealed with a 1/4 NPT pipe plug. The pump unit shall have a fully extractable head in order to permit removal of the pump motor assembly without disturbing the discharge piping or the electrical wiring. The product in the pipelines shall be held in place by a line check valve that shall have a minimum sealing of 170 lbs when the pump is not running. The line check valve shall be independent of the removable head and shall be easily accessible. The removal of the extractable portion of the pump shall not disturb product in the pipelines downstream of the check valve. During the removal of the extractable portion of the pump, product contained in the discharge manifold of the pump shall drain automatically into the storage tank. The pump motor shall be interchangeable by horsepower with different manufacturers' product.
3. Operation Specifications: The pump shall have an air/vapor elimination system that returns air or vapors to the underground storage tank through a tube discharging near the top of the pump motor assembly. The pump unit shall contain a built-in expansion relief valve that relieves pressure above pumping pressure but below 50 psi. The pump motor shall utilize the product

being pumped for lubrication of the motor bearings and for cooling the stator, and this fluid shall discharge into the underground storage tank at the top of the motor. The pump shall have siphon capability built into the pump as standard.

H. Piping System

1. All piping fittings and adhesives shall be UL listed made of fiberglass double wall. Pipe shall be in compliance with ASTM D 2996 and classified by designation code RTRP-11AF-3111. Pipe shall be filament wind of continuous glass filament. Pipe must have a minimum bend radius of 50 feet on 2" primary (80 feet on 3" secondary) to allow settling of tank. Pipe shall have maximum tensile loads of 1160 lbs, compressive loads 2210 lbs at 75 degrees Fahrenheit on 2" primary. 3" pipe shall have tensile load of 2020 lbs at 75 degrees and compressive loads of 3850 lbs. Pipe to be factory proof tested at 1000 psig-2", 700 psig-3". Pipe shall be Smith Fiberglass Red thread II, or approved equal as judged by the Owner.
2. Vent piping shall not have secondary containment. Vent shall not be sloped less than 1/4" per foot downward to tank.
3. Product piping shall have secondary containment. Product piping shall not be sloped less than 1/8" per foot downward toward tank.
4. All piping must slope back toward tank.
5. All piping must be installed as per manufacturer installation instructions. the Owner shall monitor each installation daily.

I. Leak Detection

1. Tank shall have a Pullulert FD241RRA, or approved equal, float probe mounted on the brine filled hydrostatic reservoir. The system shall monitor both the inner and outer walls of the tank.
   a. Alarm Conditions:
      1) Hydrocarbons in hydrostatic reservoir
      2) A loss of fluid in reservoir
2. Piping shall have a Pollulert FD241RRA, or approved equal, float probe mounted in the piping sump. System shall monitor the piping sump compartment that has to be designed to catch any leaked product from the primary piping system. This probe shall distinguish the difference between water and hydrocarbons and alarm on any one or both conditions.
3. Remote monitoring piping sumps shall be installed only if piping can not be sloped toward tank. The Contractor shall use as many remote monitoring piping sumps as needed to assure that all sections of piping are monitored. All monitoring sumps shall have a Pollulert FD241RRA or approved equal probe for leak detection.
4. Control panel shall have probe status for wet, dry, or hydrocarbon. Alarm conditions are to be selectable. Control panel must have installed relay or provision for installing relays for remote alarms. Control panel shall have both visual and audible alarm. System shall have a two year warranty from date of manufacture. Ground water probes shall be adjustable 1/8" to 2" for product detection. Probes shall be wired by a single cable run. Systems must be UL listed for Class 1, Division 1, Group D locations and meet all existing EPA regulations. Leak detection shall be Pollulert systems or approved equal.
5. Submersible pump shall have a mechanical in-line leak detector with a free floating check valve. Leak detector shall be vaporless LD2000 or approved equal.

J. In Tank Gauging System

1. Gauging system shall provide inventory management designed to continuously monitor underground storage tanks. System must provide information on inventory, delivery of fuel, and product through-put. System must measure fuel levels, water level and fuel temperature. This is to ensure proper compensated level readings. System shall have five temperature sensors, two floats, one for product level, one for water interface. System shall have a 48 character LCD display and internal thermal printer. System shall utilize a magnetostrictive probe and have visual, audible alarm with automatic printout. The system shall be designed to have 16 input on/off devices, RS232 port full duplex with adjustable baud rate. Tank gauging system shall be Pollulert system or approved equal.

K. Test For Pipe
1. Test of the piping system shall be made per manufacturer's recommendations.
2. Furnish the Owner with a certificate stating that all piping has been tested as specified and has been shown to be tight.
3. The piping systems may be tested in sections if necessary, but a final test may be required of the entire piping system at the completion of the system. The final test shall be made while pipe is exposed to view where possible.
4. Both primary and secondary pipe must be tested.

L. Test For Tank
1. Pre-installation: All Xerxes or approved equal tanks shall be tested prior to shipment, but it is required that all tanks be tested by the Contractor prior to installation. After installation and before final backfilling to grade, the tank must be retested to assure that no damage occurred during installation.
2. Hose/Valve Assembly: In order to test the tank, the hose/valve assembly must be connected from the reservoir to a service fitting. The hose/valve assembly will already be connected from the reservoir to a service fitting when the tank is shipped. If the hose/valve assembly is not connected when the tank is delivered, contact the Customer Service Representative at the Xerxes or other plant nearest you, before attempting to test the tank.
3. Primary (Internal) Tank Test: Prior to installation, check to see that all service and monitor fittings are plugged and tightened, except the service fitting with a temporary plastic plug. Close the valve on the hose/valve assembly. Remove the temporary plastic plug and connect the pressure source to the service fitting. Pressure test the primary (internal) tank to 5 psig for 60 minutes.
4. Secondary (External) Tank Test:
   a. CAUTION: Never pressurize the secondary tank or (annular space) without connecting it to the primary tank. The secondary tank and primary tank will be properly connected if the hose/valve assembly is in place as shipped. Failure to have the secondary tank and primary tank properly connected could potentially result in tank failure and personal injury, and will void all warranties.
   b. While the primary tank is still under pressure, open the valve on the hose/valve assembly until the pressure stabilizes. Once the pressure has stabilized, either add or subtract air pressure to stabilize the pressure at 5 psig. Observe the tank for any liquid on the exterior surface and check the gauge at the pressure source for any drop in pressure.
   c. After completing the test, relieve the pressure at the source.

M. Product Dispenser
1. A fiberglass containment box shall be installed with each product dispenser. Containment box shall be as manufactured by Petro Fiberglass or approved equal. Double wall pipe shall terminate inside containment box. A flex connector as manufactured by Dana Everflex or approved equal shall be used to connect product pipe to the shear valve within the containment box. The shear valve shall be air tested at the factory and shall not lose its seal when its top is removed for service. Shear valve shall be Universal model 521 or approved equal. Each product dispensing hose shall be equipped with a re-connectable breakaway featuring a pressure balancing chamber to prevent nuisance breaks and shall disconnect at 200 lbs. A hose coupling shall separate the breakaway and hose swivel. The nozzle shall have a means of automatically stopping flow if the nozzle is not at the proper dispensing angle. Nozzle shall be of die-cast construction UL listed and have a flow equalizer to maintain 10 GPM flow. Breakaway, hose coupling, hose swivel, and nozzle shall be as manufactured by Husky or approved equal. Dispenser shall be compatible with vapor recovery systems.

END OF SECTION 15064a

SECTION 15064b - RADIANT HEATING PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for radiant heating piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes radiant heating piping, including pipes, fittings, and piping specialties.

C. Definitions
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. PEX: Crosslinked polyethylene.
3. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

D. Submittals
1. Product Data: For each type of radiant heating pipe, fitting, manifold, specialty, and control.
   a. For radiant heating piping and manifolds, include pressure and temperature rating, oxygen-barrier performance, fire-performance characteristics, and water flow and pressure drop characteristics.
2. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
3. Operation and Maintenance Data.

1.2 PRODUCTS

A. PEX Pipe And Fittings
1. Pipe Material: PEX plastic according to ASTM F 876.
2. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
3. Fittings: ASTM F 1807, metal insert and copper crimp rings.
4. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

B. PEX/AL/PEX Pipe And Fittings
1. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.
2. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
3. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
4. Flame-Spread and Smoke-Developed Indexes: 25 and 50 or less, respectively, tested according to ASTM E 84.
5. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

C. EPDM Pipe And Fittings
1. Pipe Material: Crosslinked EPDM inner and outer tubes.
2. Wall Thickness: Minimum 0.125 inch (3.2 mm).
3. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

4. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.
5. Fittings: ASTM F 1807, copper with stainless-steel crimps or clamps.
6. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

D. Distribution Manifolds
1. Manifold: Minimum NPS 1 (DN 25), brass **OR** copper **OR** modular plastic **OR** stainless steel, **as directed**.
2. Main Shutoff Valves:
   a. Factory installed on supply and return connections.
   b. Two **OR** Three, **as directed**,-piece body.
   c. Body: Brass or bronze.
   d. Ball: Chrome-plated bronze.
   e. Seals: PTFE.
   f. CWP Rating: 150 psig (1035 kPa).
   g. Maximum Operating Temperature: 225 deg F (107 deg C).
3. Manual Air Vents:
   a. Body: Bronze.
   b. Internal Parts: Nonferrous.
   c. Operator: Key furnished with valve, or screwdriver bit.
   d. Inlet Connection: NPS 1/2 (DN 15).
   e. Discharge Connection: NPS 1/8 (DN 6).
   f. CWP Rating: 150 psig (1035 kPa).
   g. Maximum Operating Temperature: 225 deg F (107 deg C).
4. Balancing Valves:
   a. Body: Plastic or bronze, ball or plug, or globe cartridge type.
   b. Ball or Plug: Brass or stainless steel.
   c. Globe Cartridge and Washer: Brass with EPDM composition washer.
   d. Seat: PTFE.
   e. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
      OR
      Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
   f. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
   g. CWP Rating: Minimum 125 psig (860 kPa).
   h. Maximum Operating Temperature: 250 deg F (121 deg C).
5. Zone Control Valves:
   a. Body: Plastic or bronze, ball or plug, or globe cartridge type.
   b. Ball or Plug: Brass or stainless steel.
   c. Globe Cartridge and Washer: Brass with EPDM composition washer.
   d. Seat: PTFE.
   e. Actuator: Replaceable electric motor.
   f. CWP Rating: Minimum 125 psig (860 kPa).
   g. Maximum Operating Temperature: 250 deg F (121 deg C).
6. Thermometers:
   a. Mount on supply and return connections.
   b. Case: Dry type, metal or plastic, 2-inch (50-mm) diameter.
   c. Element: Bourdon tube or other type of pressure element.
   d. Movement: Mechanical, connecting element and pointer.
   e. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
   f. Pointer: Black metal.
   g. Window: Plastic.
   h. Connector: Rigid, back type.
   i. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.

j. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

7. Mounting Brackets: Copper, or plastic or copper-clad steel, where in contact with manifold.

E. Piping Specialties

1. Cable Ties:
   a. Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
   b. Minimum Width: 1/8 inch (3 mm).
   c. Tensile Strength: 20 lb (9 kg), minimum.
   d. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
2. Floor-Mounting Staples:
   a. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
   b. Minimum Thickness: 3/32 inch (2.4 mm).
   c. Width: Minimum, wider than tubing.
3. Floor-Mounting Clamps:
   a. Two bolt, steel, with corrosion-resistant coating and smooth finish without sharp edges.
   b. Minimum Thickness: 3/32 inch (2.4 mm).
   c. Width: Minimum, wider than tubing.
4. Floor Mounting Tracks:
   a. Aluminum or plastic channel track with smooth finish, no sharp edges.
   b. Minimum Thickness: 1/16 inch (1.6 mm).
   c. Slot Width: Snap fit to hold tubing.
   d. Slot Spacing: 2-inch (50-mm) **OR** 3-inch (75-mm), **as directed**, intervals.
5. Channeled Subfloor:
   a. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, 7-layer, Douglas fir structural subfloor panels.
   b. Particleboard manufactured to meet Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
   c. Clad panel with minimum 0.025-inch- (0.635-mm-) thick aluminum recessed in the grooves sized to maintain contact with radiant piping.
6. Modular Interlocking Blocks:
   a. Polypropylene snap-together blocks with grooves to support piping.
   b. Galvanized sheet metal or aluminum emission plates.
   c. Natural mineralboard cover panel.
7. Heat-Emission Plates:
   a. Formed aluminum suitable for radiant heating piping.
   b. Minimum Thickness: 1/16 inch (1.6 mm).
   c. Slot Width: Snap fit to maintain pressure fit on tubing.

F. Controls

1. Temperature-control devices and sequence of operations are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
2. Wall-Mounting Thermostat:
   a. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
   b. Manually operated with on-off switch.
   c. Day and night setback and clock program with minimum four periods per day.
   d. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.
3. Heated-Panel Thermostat:
   a. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
   b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
   c. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
   d. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.

e. Corrosion-resistant, waterproof control enclosure.

4. Heated-Panel Thermostat with Outdoor Temperature Reset:
   a. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
   b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump and zone control valve.
   c. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
   d. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing outdoor-air temperature.
   e. Operate zone control valves to reset supply-water temperature inversely with outdoor-air temperature as follows:
      1) Low outdoor-air temperature, zero deg F (minus 18 deg C) with high supply-water temperature 110 deg F (43 deg C).
      2) High outdoor-air temperature, 60 deg F (16 deg C) with low supply-water temperature 70 deg F (21 deg C).
   f. Corrosion-resistant, waterproof control enclosure.
5. Precipitation and Temperature Sensor:
   a. Microprocessor-based **OR** Automatic, **as directed**, control with manual on, automatic, and standby/reset switch.
   b. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:
      1) Temperature Span: 34 to 44 deg F (1 to 7 deg C).
      2) Adjustable Delay Off Span: 30 to 90 minutes.
      3) Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
      4) Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.
   c. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
   d. Minimum 30-A contactor to start pump and open valves.
   e. Precipitation sensor shall be mounted in pavement.
   f. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

1.3 EXECUTION

A. Applications
1. Install the following types of radiant heating piping for the applications described:
   a. Piping in Exterior Pavement: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
   b. Piping in Interior Reinforced-Concrete Floors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
   c. Piping in Level Fill Concrete Floors (Not Reinforced): EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
   d. Piping in Ceilings: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
   e. Piping in Subfloors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
   f. Piping below Wood Floors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.

B. Installation
1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop or Coordination Drawings.
2. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

3. Connect radiant piping to manifold in a reverse-return arrangement.
4. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
5. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Division 08 Section "Access Doors And Frames".
6. Refer to Division 15 Section "Hydronic Piping" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
7. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Division 07 Section "Through-penetration Firestop Systems".
8. Piping in Exterior Pavement:
   a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
   b. Space cable ties a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
   c. Maintain 3-inch (75-mm) minimum cover.
   d. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
   e. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
9. Piping in Interior Reinforced-Concrete Floors:
   a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
   b. Space cable ties a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
   c. Maintain 2-inch (50-mm) minimum cover.
   d. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
   e. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
10. Piping in Level Fill Concrete Floors (Not Reinforced):
    a. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
    b. Space tracks, clamps, or staples a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
    c. Maintain 3/4-inch (19-mm) minimum cover.
    d. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
    e. Maintain minimum 40-psig (275-kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.
11. Piping in Ceiling:
    a. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
    b. Space clamps or staples a maximum of 18 inches (457 mm) o.c., and at center of turns or bends.
    c. Maintain 1-1/2-inch (38-mm) minimum plaster cover.
    d. Maintain minimum 40-psig (275-kPa) pressure in piping during the plaster application and continue for 24 hours during curing.
12. Piping in Subfloor:
    a. Secure piping by laying piping in subfloor channels or modular interlocking blocks.
    b. Use straight channel panels or blocks in the center, and curved channel panels or blocks at the ends.
    c. Finish floor with mineralboard panel cover or finished floor surface.
13. Piping below Wood Floor:
    a. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.

b. Space heat-emission plates, clamps, or staples a maximum of 4 inches (100 mm) o.c., and at center of turns or bends.
c. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.

14. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved.
15. After system balancing has been completed, mark balancing valves to permanently indicate final position.
16. Perform the following adjustments before operating the system:
    a. Open valves to fully open position.
    b. Check operation of automatic valves.
    c. Set temperature controls so all zones call for full flow.
    d. Purge air from piping.
17. After the concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant heating system as follows:
    a. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant panel temperature, and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
    b. For freeze protection, operate at a maximum of 60 deg F (16 deg C) supply-water temperature.

C. Field Quality Control
1. Prepare radiant heating piping for testing as follows:
    a. Open all isolation valves and close bypass valves.
    b. Open and verify operation of zone control valves.
    c. Flush with clean water, and clean strainers.
2. Tests and Inspections:
    a. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa). Repair leaks and retest until no leaks exist.
    b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning radiant heating piping components that do not pass tests, and retest as specified above.
4. Prepare a written report of testing.

END OF SECTION 15064b

Task	Specification	Specification Description
15064	02242	Piped Utilities Basic Materials And Methods
15064	02455a	Water Distribution
15064	02464a	Monitoring Wells
15064	02456	Water Supply Wells
15064	02455b	Sanitary Sewerage
15064	15061	Common Work Results for Fire Suppression
15064	15061a	Common Work Results for Plumbing
15064	15061b	Common Work Results for HVAC
15064	15061c	Domestic Water Piping
15064	15061d	Sanitary Waste And Vent Piping
15064	15061e	Storm Drainage Piping
15064	15061f	Hydronic Piping
15064	15063	Compressed-Air Piping For Laboratory And Healthcare Facilities
15064	15063a	Vacuum Piping For Laboratory And Healthcare Facilities
15064	15063b	Gas Piping For Laboratory And Healthcare Facilities
15072	15064	Relief Wells
15072	02464a	Monitoring Wells
15072	02456	Water Supply Wells
15072	02455b	Sanitary Sewerage
15072	15061	Common Work Results for Fire Suppression
15072	15061a	Common Work Results for Plumbing
15072	15061b	Common Work Results for HVAC
15072	02551	Facility Natural-Gas Piping
15072	02551a	Facility Liquefied-Petroleum Gas Piping
15075	02242	Piped Utilities Basic Materials And Methods
15075	15061	Common Work Results for Fire Suppression
15075	15061a	Common Work Results for Plumbing
15075	15061b	Common Work Results for HVAC
15075	15061d	Sanitary Waste And Vent Piping

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SECTION 15080 - METERS AND GAGES FOR PLUMBING PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for meters and gages for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Bimetallic-actuated thermometers.
b. Filled-system thermometers.
c. Liquid-in-glass thermometers.
d. Light-activated thermometers.
e. Thermowells.
f. Dial-type pressure gages.
g. Gage attachments.
h. Test plugs.
i. Test-plug kits.
j. Sight flow indicators.

C. Submittals
1. Product Data: For each type of product indicated.
2. Product Certificates: For each type of meter and gage, from manufacturer.
3. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.2 PRODUCTS

A. Bimetallic-Actuated Thermometers
1. Standard: ASME B40.200.
2. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) **OR** 5-inch (127-mm), **as directed**, nominal diameter.
3. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C) **OR** deg F and deg C, **as directed**.
4. Connector Type(s): Union joint, adjustable angle **OR** rigid, back **OR** rigid, bottom, **as directed**, with unified-inch screw threads.
5. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
6. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
7. Window: Plain glass or plastic.
8. Ring: Stainless steel.
9. Element: Bimetal coil.
10. Pointer: Dark-colored metal.
11. Accuracy: Plus or minus 1 **OR** 1.5, **as directed**, percent of scale range.

B. Filled-System Thermometers
1. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
a. Standard: ASME B40.200.
b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
c. Element: Bourdon tube or other type of pressure element.

d. Movement: Mechanical, dampening type, **as directed**, with link to pressure element and connection to pointer.
e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
f. Pointer: Dark-colored metal.
g. Window: Glass or plastic.
h. Ring: Metal **OR** Stainless steel, **as directed**.
i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
   1) Design for Thermowell Installation: Bare stem.
k. Accuracy: Plus or minus 1 percent of scale range.

2. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
   c. Element: Bourdon tube or other type of pressure element.
   d. Movement: Mechanical, with link to pressure element and connection to pointer.
   e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Pointer: Dark-colored metal.
   g. Window: Glass or plastic.
   h. Ring: Metal or plastic.
   i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
   j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   k. Accuracy: Plus or minus 1 percent of scale range.

3. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
   c. Element: Bourdon tube or other type of pressure element.
   d. Movement: Mechanical, with link to pressure element and connection to pointer.
   e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Pointer: Dark-colored metal.
   g. Window: Glass or plastic.
   h. Ring: Metal **OR** Stainless steel, **as directed**.
   i. Connector Type(s): Union joint, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
   j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   k. Accuracy: Plus or minus 1 percent of scale range.

4. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
   c. Element: Bourdon tube or other type of pressure element.

d. Movement: Mechanical, with link to pressure element and connection to pointer.
e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
f. Pointer: Dark-colored metal.
g. Window: Glass or plastic.
h. Ring: Metal or plastic.
i. Connector Type(s): Union joint, threaded, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
   1) Design for Thermowell Installation: Bare stem.
k. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Liquid-In-Glass Thermometers
1. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Cast aluminum; 6-inch (152-mm) nominal size.
   c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
   d. Tube: Glass with magnifying lens and blue or red organic liquid.
   e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Window: Glass or plastic.
   g. Stem: Aluminum or brass and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
   i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
2. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Plastic; 6-inch (152-mm) nominal size.
   c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
   d. Tube: Glass with magnifying lens and blue or red organic liquid.
   e. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Window: Glass or plastic.
   g. Stem: Aluminum or brass and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
   i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
3. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Cast aluminum; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
   c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
   d. Tube: Glass with magnifying lens and blue or red organic liquid.
   e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Window: Glass or plastic.
   g. Stem: Aluminum and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
   i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

4. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Plastic; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
   c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
   d. Tube: Glass with magnifying lens and blue or red organic liquid.
   e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Window: Glass or plastic.
   g. Stem: Aluminum **OR** Brass **OR** Stainless steel **OR** Aluminum, brass, or stainless steel, **as directed**, and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
   i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Light-Activated Thermometers
1. Direct-Mounted, Light-Activated Thermometers:
   a. Case: Plastic **OR** Metal, **as directed**; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
   b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
   c. Case Form: Adjustable angle.
   d. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
   e. Stem: Aluminum and of length to suit installation.
      1) Design for Thermowell Installation: Bare stem.
   f. Display: Digital.
   g. Accuracy: Plus or minus 2 deg F (1 deg C).
2. Remote-Mounted, Light-Activated Thermometers:
   a. Case: Plastic, for wall mounting.
   b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
   c. Sensor: Bulb and thermister wire.
      1) Design for Thermowell Installation: Bare stem.
   d. Display: Digital.
   e. Accuracy: Plus or minus 2 deg F (1 deg C).

E. Thermowells
1. Thermowells:
   a. Standard: ASME B40.200.
   b. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
   c. Material for Use with Copper Tubing: CNR or CUNI.
   d. Material for Use with Steel Piping: CRES **OR** CSA, **as directed**.
   e. Type: Stepped shank unless straight or tapered shank is indicated.
   f. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
   g. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
   h. Bore: Diameter required to match thermometer bulb or stem.
   i. Insertion Length: Length required to match thermometer bulb or stem.
   j. Lagging Extension: Include on thermowells for insulated piping and tubing.
   k. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
2. Heat-Transfer Medium: Mixture of graphite and glycerin.

F. Pressure Gages

1. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
   a. Standard: ASME B40.100.
   b. Case: Liquid-filled **OR** Sealed **OR** Open-front, pressure relief **OR** Solid-front, pressure relief, **as directed**, type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
   c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   e. Movement: Mechanical, with link to pressure element and connection to pointer.
   f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
   g. Pointer: Dark-colored metal.
   h. Window: Glass or plastic.
   i. Ring: Metal **OR** Brass **OR** Stainless steel, **as directed**.
   j. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
2. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
   a. Standard: ASME B40.100.
   b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
   c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   e. Movement: Mechanical, with link to pressure element and connection to pointer.
   f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
   g. Pointer: Dark-colored metal.
   h. Window: Glass or plastic.
   i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
3. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
   a. Standard: ASME B40.100.
   b. Case: Liquid-filled **OR** Sealed, **as directed**, type; cast aluminum or drawn steel **OR** metal, **as directed**; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
   c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   e. Movement: Mechanical, with link to pressure element and connection to pointer.
   f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
   g. Pointer: Dark-colored metal.
   h. Window: Glass or plastic.
   i. Ring: Metal **OR** Stainless steel, **as directed**.
   j. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
4. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
   a. Standard: ASME B40.100.
   b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.

c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
e. Movement: Mechanical, with link to pressure element and connection to pointer.
f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
g. Pointer: Dark-colored metal.
h. Window: Glass or plastic.
i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.

G. Gage Attachments
1. Snubbers: ASME B40.100, brass; with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and piston **OR** porous-metal, **as directed**,-type surge-dampening device. Include extension for use on insulated piping.
2. Valves: Brass ball **OR** Brass or stainless-steel needle, **as directed**, with NPS 1/4 (DN 8) **OR** NPS 1/4 or NPS 1/2 (DN 8 or DN 15) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads.

H. Test Plugs
1. Description: Test-station fitting made for insertion into piping tee fitting.
2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
3. Thread Size: NPS 1/4 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.
4. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
5. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

I. Test-Plug Kits
1. Furnish one test-plug kit(s) containing one **OR** two, **as directed**, thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
2. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
3. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
4. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
5. Carrying Case: Metal or plastic, with formed instrument padding.

J. Sight Flow Indicators
1. Description: Piping inline-installation device for visual verification of flow.
2. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
3. Minimum Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1034 kPa), **as directed**.
4. Minimum Temperature Rating: 200 deg F (93 deg C).
5. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
6. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

1.3 EXECUTION

A. Installation
1. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid **OR** one-third of pipe diameter **OR** to center of pipe, **as directed**, and in vertical position in piping tees.
2. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
3. Install thermowells with extension on insulated piping.
4. Fill thermowells with heat-transfer medium.
5. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
6. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
7. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
8. Install remote-mounted pressure gages on panel.
9. Install valve and snubber in piping for each pressure gage for fluids.
10. Install test plugs in piping tees.
11. Install thermometers in the following locations:
    a. Inlet and outlet of each water heater.
    b. Inlets and outlets of each domestic water heat exchanger.
    c. Inlet and outlet of each domestic hot-water storage tank.
    d. Inlet and outlet of each remote domestic water chiller.
12. Install pressure gages in the following locations:
    a. Building water service entrance into building.
    b. Inlet and outlet of each pressure-reducing valve.
    c. Suction and discharge of each domestic water pump.

B. Connections
1. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

C. Adjusting
1. Adjust faces of meters and gages to proper angle for best visibility.

D. Thermometer Schedule
1. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
    a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
    b. Direct **OR** Remote, **as directed**,-mounted, metal **OR** plastic, **as directed**,-case, vapor-actuated type.
    c. Compact **OR** Industrial, **as directed**,-style, liquid-in-glass type.
    d. Direct **OR** Remote, **as directed**,-mounted, light-activated type.
    e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
2. Thermometers at inlets and outlets of each domestic water heat exchanger shall be one of the following:
    a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
    b. Direct **OR** Remote, **as directed**,-mounted, metal **OR** plastic, **as directed**,-case, vapor-actuated type.
    c. Compact **OR** Industrial, **as directed**,-style, liquid-in-glass type.
    d. Direct **OR** Remote, **as directed**,-mounted, light-activated type.
    e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
3. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be one of the following:
    a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.

b. Direct **OR** Remote, **as directed**,-mounted, metal **OR** plastic, **as directed**,-case, vapor-actuated type.
c. Compact **OR** Industrial, **as directed**,-style, liquid-in-glass type.
d. Direct **OR** Remote, **as directed**,-mounted, light-activated type.
e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.

4. Thermometers at inlet and outlet of each remote domestic water chiller shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct **OR** Remote, **as directed**,-mounted, metal **OR** plastic, **as directed**,-case, vapor-actuated type.
   c. Compact **OR** Industrial, **as directed**,-style, liquid-in-glass type.
   d. Direct **OR** Remote, **as directed**,-mounted, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
5. Thermometer stems shall be of length to match thermowell insertion length.

E. Thermometer Scale-Range Schedule
1. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
2. Scale Range for Domestic Cold-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
3. Scale Range for Domestic Cold-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
4. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
5. Scale Range for Domestic Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
6. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
7. Scale Range for Domestic Cooled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
8. Scale Range for Domestic Cooled-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.

F. Pressure-Gage Schedule
1. Pressure gages at discharge of each water service into building shall be one of the following:
   a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct **OR** remote, **as directed**,-mounted, metal case.
   b. Sealed, direct **OR** remote, **as directed**,-mounted, plastic case.
   c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
2. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be one of the following:
   a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct **OR** remote, **as directed**,-mounted, metal case.
   b. Sealed, direct **OR** remote, **as directed**,-mounted, plastic case.
   c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
3. Pressure gages at suction and discharge of each domestic water pump shall be one of the following:
   a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct **OR** remote, **as directed**,-mounted, metal case.
   b. Sealed, direct **OR** remote, **as directed**,-mounted, plastic case.

c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.

G. Pressure-Gage Scale-Range Schedule

1. Scale Range for Water Service Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
2. Scale Range for Water Service Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
3. Scale Range for Water Service Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
4. Scale Range for Domestic Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
5. Scale Range for Domestic Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
6. Scale Range for Domestic Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
7. Scale Range for Domestic Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.

END OF SECTION 15080

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SECTION 15080a - METERS AND GAGES FOR HVAC PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for meters and gages for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Bimetallic-actuated thermometers.
b. Filled-system thermometers.
c. Liquid-in-glass thermometers.
d. Light-activated thermometers.
e. Thermowells.
f. Dial-type pressure gages.
g. Gage attachments.
h. Test plugs.
i. Test-plug kits.
j. Sight flow indicators.
k. Orifice flowmeters.
l. Pitot-tube flowmeters.
m. Turbine flowmeters.
n. Venturi flowmeters.
o. Vortex-shedding flowmeters.
p. Impeller-turbine, thermal-energy meters.
q. Ultrasonic, thermal-energy meters.

C. Submittals
1. Product Data: For each type of product indicated.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Product Certificates: For each type of meter and gage, from manufacturer.
4. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.2 PRODUCTS

A. Bimetallic-Actuated Thermometers
1. Standard: ASME B40.200.
2. Case: Liquid-filled and sealed type(s); stainless steel with 3-inch (76-mm) **OR** 5-inch (127-mm), **as directed**, nominal diameter.
3. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F (deg C) **OR** deg F and deg C, **as directed**.
4. Connector Type(s): Union joint, adjustable angle **OR** rigid, back **OR** rigid, bottom, **as directed**, with unified-inch screw threads.
5. Connector Size: 1/2 inch (13 mm), with ASME B1.1 screw threads.
6. Stem: 0.25 or 0.375 inch (6.4 or 9.4 mm) in diameter; stainless steel.
7. Window: Plain glass or plastic.
8. Ring: Stainless steel.
9. Element: Bimetal coil.
10. Pointer: Dark-colored metal.

11. Accuracy: Plus or minus 1 **OR** 1.5, **as directed**, percent of scale range.

B. Filled-System Thermometers
1. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
   c. Element: Bourdon tube or other type of pressure element.
   d. Movement: Mechanical, dampening type, **as directed**, with link to pressure element and connection to pointer.
   e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Pointer: Dark-colored metal.
   g. Window: Glass or plastic.
   h. Ring: Metal **OR** Stainless steel.
   i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
   j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
      1) Design for Air-Duct Installation: With ventilated shroud.
      2) Design for Thermowell Installation: Bare stem.
   k. Accuracy: Plus or minus 1 percent of scale range.
2. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 5-inch (127-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
   c. Element: Bourdon tube or other type of pressure element.
   d. Movement: Mechanical, with link to pressure element and connection to pointer.
   e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Pointer: Dark-colored metal.
   g. Window: Glass or plastic.
   h. Ring: Metal or plastic.
   i. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device **OR** rigid, back **OR** rigid, bottom, **as directed**; with ASME B1.1 screw threads.
   j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
      1) Design for Air-Duct Installation: With ventilated shroud.
      2) Design for Thermowell Installation: Bare stem.
   k. Accuracy: Plus or minus 1 percent of scale range.
3. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
   c. Element: Bourdon tube or other type of pressure element.
   d. Movement: Mechanical, with link to pressure element and connection to pointer.
   e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Pointer: Dark-colored metal.
   g. Window: Glass or plastic.
   h. Ring: Metal **OR** Stainless steel, **as directed**.

i. Connector Type(s): Union joint, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
1) Design for Air-Duct Installation: With ventilated shroud.
2) Design for Thermowell Installation: Bare stem.
k. Accuracy: Plus or minus 1 percent of scale range.

4. Remote-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
a. Standard: ASME B40.200.
b. Case: Sealed type, plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
c. Element: Bourdon tube or other type of pressure element.
d. Movement: Mechanical, with link to pressure element and connection to pointer.
e. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
f. Pointer: Dark-colored metal.
g. Window: Glass or plastic.
h. Ring: Metal or plastic.
i. Connector Type(s): Union joint, threaded, back **OR** bottom, **as directed**; with ASME B1.1 screw threads.
j. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
1) Design for Air-Duct Installation: With ventilated shroud.
2) Design for Thermowell Installation: Bare stem.
k. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

C. Liquid-In-Glass Thermometers
1. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
a. Standard: ASME B40.200.
b. Case: Cast aluminum; 6-inch (152-mm) nominal size.
c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
f. Window: Glass or plastic.
g. Stem: Aluminum or brass and of length to suit installation.
1) Design for Air-Duct Installation: With ventilated shroud.
2) Design for Thermowell Installation: Bare stem.
h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
a. Standard: ASME B40.200.
b. Case: Plastic; 6-inch (152-mm) nominal size.
c. Case Form: Back angle **OR** Straight, **as directed**, unless otherwise indicated.
d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
e. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
f. Window: Glass or plastic.
g. Stem: Aluminum or brass and of length to suit installation.
1) Design for Air-Duct Installation: With ventilated shroud.
2) Design for Thermowell Installation: Bare stem.
h. Connector: 3/4 inch (19 mm), with ASME B1.1 screw threads.
i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

3. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Cast aluminum; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
   c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
   d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
   e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Window: Glass or plastic.
   g. Stem: Aluminum and of length to suit installation.
      1) Design for Air-Duct Installation: With ventilated shroud.
      2) Design for Thermowell Installation: Bare stem.
   h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
   i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
4. Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:
   a. Standard: ASME B40.200.
   b. Case: Plastic; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
   c. Case Form: Adjustable angle **OR** Back angle **OR** Straight, **as directed**, unless otherwise indicated.
   d. Tube: Glass with magnifying lens and blue or red, **as directed**, organic liquid.
   e. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C) **OR** deg F and deg C, **as directed**.
   f. Window: Glass or plastic.
   g. Stem: Aluminum **OR** Brass **OR** Stainless steel, **as directed**, and of length to suit installation.
      1) Design for Air-Duct Installation: With ventilated shroud.
      2) Design for Thermowell Installation: Bare stem.
   h. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
   i. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

D. Light-Activated Thermometers
1. Direct-Mounted, Light-Activated Thermometers:
   a. Case: Plastic **OR** Metal, **as directed**; 7-inch (178-mm) **OR** 9-inch (229-mm), **as directed**, nominal size unless otherwise indicated.
   b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
   c. Case Form: Adjustable angle.
   d. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
   e. Stem: Aluminum and of length to suit installation.
      1) Design for Air-Duct Installation: With ventilated shroud.
      2) Design for Thermowell Installation: Bare stem.
   f. Display: Digital.
   g. Accuracy: Plus or minus 2 deg F (1 deg C).
2. Remote-Mounted, Light-Activated Thermometers:
   a. Case: Plastic, for wall mounting.
   b. Scale(s): Deg F (Deg C) **OR** Deg F and deg C, **as directed**.
   c. Sensor: Bulb and thermister wire.
      1) Design for Air-Duct Installation: With ventilated shroud.
      2) Design for Thermowell Installation: Bare stem.
   d. Display: Digital.
   e. Accuracy: Plus or minus 2 deg F (1 deg C).

E. Duct-Thermometer Mounting Brackets
   1. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

F. Thermowells
   1. Thermowells:
      a. Standard: ASME B40.200.
      b. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
      c. Material for Use with Copper Tubing: CNR **OR** CUNI, **as directed**.
      d. Material for Use with Steel Piping: CRES **OR** CSA, **as directed**.
      e. Type: Stepped shank unless straight or tapered shank is indicated.
      f. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
      g. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
      h. Bore: Diameter required to match thermometer bulb or stem.
      i. Insertion Length: Length required to match thermometer bulb or stem.
      j. Lagging Extension: Include on thermowells for insulated piping and tubing.
      k. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
   2. Heat-Transfer Medium: Mixture of graphite and glycerin.

G. Pressure Gages
   1. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
      1) Standard: ASME B40.100.
      2) Case: Liquid-filled **OR** Sealed **OR** Open-front, pressure relief **OR** Solid-front, pressure relief, **as directed**, type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
      3) Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
      4) Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
      5) Movement: Mechanical, with link to pressure element and connection to pointer.
      6) Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
      7) Pointer: Dark-colored metal.
      8) Window: Glass or plastic.
      9) Ring: Metal **OR** Brass **OR** Stainless steel, **as directed**.
      10) Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
   2. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
      a. Standard: ASME B40.100.
      b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter.
      c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
      d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
      e. Movement: Mechanical, with link to pressure element and connection to pointer.
      f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
      g. Pointer: Dark-colored metal.
      h. Window: Glass or plastic.
      i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.

3. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
   a. Standard: ASME B40.100.
   b. Case: Liquid-filled **OR** Sealed, **as directed**, type; cast aluminum or drawn steel **OR** metal, **as directed**; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
   c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   e. Movement: Mechanical, with link to pressure element and connection to pointer.
   f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
   g. Pointer: Dark-colored metal.
   h. Window: Glass or plastic.
   i. Ring: Metal **OR** Stainless steel, **as directed**.
   j. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.
4. Remote-Mounted, Plastic-Case, Dial-Type Pressure Gages:
   a. Standard: ASME B40.100.
   b. Case: Sealed type; plastic; 4-1/2-inch (114-mm) **OR** 6-inch (152-mm), **as directed**, nominal diameter with back **OR** front, **as directed**, flange and holes for panel mounting.
   c. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
   d. Pressure Connection: Brass, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
   e. Movement: Mechanical, with link to pressure element and connection to pointer.
   f. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi (kPa) **OR** psi and kPa, **as directed**.
   g. Pointer: Dark-colored metal.
   h. Window: Glass or plastic.
   i. Accuracy: Grade A, plus or minus 1 percent of middle half of **OR** Grade B, plus or minus 2 percent of middle half of **OR** Grade C, plus or minus 3 percent of middle half of **OR** Grade D, plus or minus 5 percent of whole, **as directed**, scale range.

H. Gage Attachments
1. Snubbers: ASME B40.100, brass; with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads and piston-type **OR** porous-metal-type, **as directed**, surge-dampening device. Include extension for use on insulated piping.
2. Siphons: Loop-shaped section of brass **OR** stainless-steel **OR** steel, **as directed**, pipe with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, pipe threads.
3. Valves: Brass ball **OR** Brass or stainless-steel needle, **as directed**, with NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe threads.

I. Test Plugs
1. Description: Test-station fitting made for insertion into piping tee fitting.
2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
3. Thread Size: NPS 1/4 (DN 8) **OR** NPS 1/2 (DN 15), **as directed**, ASME B1.20.1 pipe thread.
4. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
5. Core Inserts: Chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber.

J. Test-Plug Kits
1. Furnish one test-plug kit(s) containing one **OR** two, **as directed**, thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

2. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
3. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
4. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
5. Carrying Case: Metal or plastic, with formed instrument padding.

K. Sight Flow Indicators
1. Description: Piping inline-installation device for visual verification of flow.
2. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
3. Minimum Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1034 kPa), **as directed**.
4. Minimum Temperature Rating: 200 deg F (93 deg C).
5. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
6. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

L. Flowmeters
1. Orifice Flowmeters:
   a. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
   b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
   c. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.
      1) Design: Differential-pressure-type measurement for gas **OR** oil **OR** steam **OR** water, **as directed**.
      2) Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
      3) Minimum Pressure Rating: 300 psig (2070 kPa).
      4) Minimum Temperature Rating: 250 deg F (121 deg C).
   d. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.
      1) Scale: Gallons per minute (Liters per second).
      2) Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.
   e. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected sensor and having two 12-foot (3.7-m) hoses, with carrying case.
      1) Scale: Gallons per minute (Liters per second).
      2) Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
   f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
   g. Conversion Chart: Flow rate data compatible with sensor and indicator.
   h. Operating Instructions: Include complete instructions with each flowmeter.
2. Pitot-Tube Flowmeters:
   a. Description: Flowmeter with sensor and indicator.
   b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
   c. Sensor: Insertion type; for inserting probe into piping and measuring flow directly in gallons per minute (liters per second).
      1) Design: Differential-pressure-type measurement for oil **OR** water, **as directed**.
      2) Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
      3) Minimum Pressure Rating: 150 psig (1035 kPa).
      4) Minimum Temperature Rating: 250 deg F (121 deg C).

d. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
e. Integral Transformer: For low-voltage power connection.
f. Accuracy: Plus or minus 3 percent.
g. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
h. Operating Instructions: Include complete instructions with each flowmeter.

3. Turbine Flowmeters:
   a. Description: Flowmeter with sensor and indicator.
   b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
   c. Sensor: Impeller turbine; for inserting into pipe fitting or for installing in piping and measuring flow directly in gallons per minute (liters per second).
      1) Design: Device or pipe fitting with inline turbine and integral direct-reading scale for gas **OR** oil **OR** steam **OR** water, **as directed**.
      2) Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
      3) Minimum Pressure Rating: 150 psig (1035 kPa).
      4) Minimum Temperature Rating: 180 deg F (82 deg C).
   d. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
   e. Accuracy: Plus or minus 1-1/2 percent.
   f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
   g. Operating Instructions: Include complete instructions with each flowmeter.
4. Venturi Flowmeters:
   a. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.
   b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
   c. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
      1) Design: Differential-pressure-type measurement for gas **OR** oil **OR** steam **OR** water, **as directed**.
      2) Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
      3) Minimum Pressure Rating: 250 psig (1725 kPa).
      4) Minimum Temperature Rating: 250 deg F (121 deg C).
      5) End Connections for NPS 2 (DN 50) and Smaller: Threaded.
      6) End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
      7) Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.
   d. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
      1) Scale: Gallons per minute (Liters per second).
      2) Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.
   e. Portable Indicators: Hand-held, differential-pressure type, calibrated for connected flowmeter element and having two 12-foot (3.7-m) hoses, with carrying case.
      1) Scale: Gallons per minute (Liters per second).
      2) Accuracy: Plus or minus 2 percent between 20 and 80 percent of scale range.
   f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
   g. Conversion Chart: Flow rate data compatible with sensor.
   h. Operating Instructions: Include complete instructions with each flowmeter.
5. Vortex-Shedding Flowmeters:
   a. Description: Flowmeter with sensor and indicator.
   b. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
   c. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute (liters per second).

1) Design: Flow obstruction device, vortex-measurement type for gas **OR** steam **OR** liquids, **as directed**.
2) Construction: Stainless-steel body, with integral transmitter and direct-reading scale.
3) Minimum Pressure Rating: 1000 psig (6900 kPa).
4) Minimum Temperature Rating: 500 deg F (260 deg C).
5) Integral Transformer: For low-voltage power operation.

d. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
e. Accuracy: Plus or minus 0.25 percent for liquids and 0.75 percent for gases.
f. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
g. Operating Instructions: Include complete instructions with each flowmeter.

M. Thermal-Energy Meters

1. Impeller-Turbine, Thermal-Energy Meters:
   a. Description: System with strainer, **as directed**, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
   b. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.
      1) Design: Total thermal-energy measurement.
      2) Minimum Pressure Rating: 150 psig (1035 kPa).
      3) Minimum Temperature Range: 40 to 250 deg F (5 to 121 deg C).
   c. Temperature Sensors: Insertion-type transducer.
   d. Indicator: Solid-state, integrating-type meter with integral battery pack, **as directed**; for wall mounting.
      1) Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
      2) Battery Pack: Five-year lithium battery.
   e. Accuracy: Plus or minus 1 percent.
   f. Display: Visually indicates total fluid volume in gallons (liters) and thermal-energy flow in kilowatts per hour or British thermal units (joules).
   g. Strainer: Full size of main line piping.
   h. Operating Instructions: Include complete instructions with each thermal-energy meter system.
2. Ultrasonic, Thermal-Energy Meters:
   a. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
   b. Flow Sensor: Transit-time ultrasonic type with transmitter.
   c. Temperature Sensors: Insertion-type or strap-on transducer.
   d. Indicator: Solid-state, integrating-type meter with integral battery pack, **as directed**.
      1) Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units (joules).
      2) Battery Pack: Five-year lithium battery.
   e. Accuracy: Plus or minus 1 percent.
   f. Display: Visually indicates total fluid volume in gallons (liters) and thermal-energy flow in kilowatts per hour or British thermal units (joules).
   g. Operating Instructions: Include complete instructions with each thermal-energy meter system.

1.3 EXECUTION

A. Installation

1. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid **OR** one-third of pipe diameter **OR** to center of pipe, **as directed**, and in vertical position in piping tees.
2. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

3. Install thermowells with extension on insulated piping.
4. Fill thermowells with heat-transfer medium.
5. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
6. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
7. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
8. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
9. Install remote-mounted pressure gages on panel.
10. Install valve and snubber in piping for each pressure gage for fluids (except steam).
11. Install valve and syphon fitting in piping for each pressure gage for steam.
12. Install test plugs in piping tees.
13. Install flow indicators in piping systems in accessible positions for easy viewing.
14. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
15. Install flowmeter elements in accessible positions in piping systems.
16. Install wafer-orifice flowmeter elements between pipe flanges.
17. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
18. Install permanent indicators on walls or brackets in accessible and readable positions.
19. Install connection fittings in accessible locations for attachment to portable indicators.
20. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
21. Install thermometers in the following locations:
    a. Inlet and outlet of each hydronic zone.
    b. Inlet and outlet of each hydronic boiler.
    c. Two inlets and two outlets of each chiller.
    d. Inlet and outlet of each hydronic coil in air-handling units.
    e. Two inlets and two outlets of each hydronic heat exchanger.
    f. Inlet and outlet of each thermal-storage tank.
    g. Outside-, return-, supply-, and mixed-air ducts.
22. Install pressure gages in the following locations:
    a. Discharge of each pressure-reducing valve.
    b. Inlet and outlet of each chiller chilled-water and condenser-water connection.
    c. Suction and discharge of each pump.

B. Connections
1. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.
2. Connect flowmeter-system elements to meters.
3. Connect flowmeter transmitters to meters.
4. Connect thermal-energy meter transmitters to meters.

C. Adjusting
1. After installation, calibrate meters according to manufacturer's written instructions.
2. Adjust faces of meters and gages to proper angle for best visibility.

D. Thermometer Schedule
1. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
    a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
    b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
    c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
    d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
    e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.

2. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
3. Thermometers at inlets and outlets of each chiller shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
4. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
5. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
6. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
7. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
   e. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
8. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
   a. Liquid-filled **OR** Sealed, **as directed**, bimetallic-actuated type.
   b. Direct-mounted **OR** Remote-mounted, **as directed**, metal-case **OR** plastic-case, **as directed**, vapor-actuated type.
   c. Compact-style **OR** Industrial-style, **as directed**, liquid-in-glass type.
   d. Direct-mounted **OR** Remote-mounted, **as directed**, light-activated type.
9. Thermometer stems shall be of length to match thermowell insertion length.

E. Thermometer Scale-Range Schedule

1. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C) **OR** Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C, **as directed**.
2. Scale Range for Chilled-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
3. Scale Range for Chilled-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
4. Scale Range for Chilled-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
5. Scale Range for Condenser-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
6. Scale Range for Condenser-Water Piping: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
7. Scale Range for Condenser-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
8. Scale Range for Condenser-Water Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
9. Scale Range for Condenser-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
10. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
11. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
12. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
13. Scale Range for Heating, Hot-Water Piping: 50 to 400 deg F (0 to 200 deg C) **OR** 50 to 400 deg F and 0 to 200 deg C, **as directed**.
14. Scale Range for Heating, Hot-Water Piping: 50 to 550 deg F (10 to 300 deg C) **OR** 50 to 550 deg F and 10 to 300 deg C, **as directed**.
15. Scale Range for Steam and Steam-Condensate Piping: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
16. Scale Range for Steam and Steam-Condensate Piping: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
17. Scale Range for Steam and Steam-Condensate Piping: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed**.
18. Scale Range for Steam and Steam-Condensate Piping: 50 to 400 deg F (0 to 200 deg C) **OR** 50 to 400 deg F and 0 to 200 deg C, **as directed**.
19. Scale Range for Air Ducts: Minus 40 to plus 110 deg F (Minus 40 to plus 45 deg C) **OR** Minus 40 to plus 110 deg F and minus 40 to plus 45 deg C, **as directed**.
20. Scale Range for Air Ducts: Minus 40 to plus 160 deg F (Minus 40 to plus 100 deg C) **OR** Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C, **as directed**.
21. Scale Range for Air Ducts: 0 to 100 deg F (Minus 20 to plus 50 deg C) **OR** 0 to 100 deg F and minus 20 to plus 50 deg C, **as directed**.
22. Scale Range for Air Ducts: 0 to 150 deg F (Minus 20 to plus 70 deg C) **OR** 0 to 150 deg F and minus 20 to plus 70 deg C, **as directed**.
23. Scale Range for Air Ducts: 0 to 250 deg F (0 to 150 deg C) **OR** 0 to 250 deg F and 0 to 150 deg C, **as directed**.
24. Scale Range for Air Ducts: 20 to 240 deg F (0 to 150 deg C) **OR** 20 to 240 deg F and 0 to 150 deg C, **as directed**.
25. Scale Range for Air Ducts: 30 to 240 deg F (0 to plus 115 deg C) **OR** 30 to 240 deg F and 0 to plus 115 deg C, **as directed.**
26. Scale Range for Air Ducts: 50 to 400 deg F (0 to 200 deg C) **OR** 50 to 400 deg F and 0 to 200 deg C, **as directed**.

F. Pressure-Gage Schedule

1. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:
   a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct-mounted **OR** remote-mounted, **as directed**, metal case.
   b. Sealed, direct-mounted **OR** remote-mounted, **as directed**, plastic case.
   c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
2. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
   a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct-mounted **OR** remote-mounted, **as directed**, metal case.
   b. Sealed, direct-mounted **OR** remote-mounted, **as directed**, plastic case.
   c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.
3. Pressure gages at suction and discharge of each pump shall be one of the following:
   a. Liquid-filled **OR** Sealed **OR** Open-front, pressure-relief **OR** Solid-front, pressure-relief, **as directed**, direct-mounted **OR** remote-mounted, **as directed**, metal case.
   b. Sealed, direct-mounted **OR** remote-mounted, **as directed**, plastic case.
   c. Test plug with chlorosulfonated polyethylene synthetic **OR** EPDM, **as directed**, self-sealing rubber inserts.

G. Pressure-Gage Scale-Range Schedule
1. Scale Range for Chilled-Water Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kP, **as directed**.
2. Scale Range for Chilled-Water Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kP, **as directed**.
3. Scale Range for Chilled-Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kP, **as directed**.
4. Scale Range for Chilled-Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kP, **as directed**.
5. Scale Range for Chilled-Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
6. Scale Range for Chilled-Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
7. Scale Range for Chilled-Water Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.
8. Scale Range for Condenser-Water Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
9. Scale Range for Condenser-Water Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
10. Scale Range for Condenser-Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
11. Scale Range for Condenser-Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
12. Scale Range for Condenser-Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
13. Scale Range for Condenser-Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
14. Scale Range for Condenser-Water Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.
15. Scale Range for Heating, Hot-Water Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
16. Scale Range for Heating, Hot-Water Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
17. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.

18. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
19. Scale Range for Heating, Hot-Water Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
20. Scale Range for Heating, Hot-Water Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
21. Scale Range for Heating, Hot-Water Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.
22. Scale Range for Steam Piping: 30 in. Hg to 15 psi (minus 100 to 0 kPa) **OR** 30 in. Hg to 15 psi and minus 100 to 0 kPa, **as directed**.
23. Scale Range for Steam Piping: 0 to 30 psi (0 to 240 kPa) **OR** 0 to 30 psi and 0 to 240 kPa, **as directed**.
24. Scale Range for Steam Piping: 0 to 100 psi (0 to 600 kPa) **OR** 0 to 100 psi and 0 to 600 kPa, **as directed**.
25. Scale Range for Steam Piping: 0 to 160 psi (0 to 1100 kPa) **OR** 0 to 160 psi and 0 to 1100 kPa, **as directed**.
26. Scale Range for Steam Piping: 0 to 200 psi (0 to 1400 kPa) **OR** 0 to 200 psi and 0 to 1400 kPa, **as directed**.
27. Scale Range for Steam Piping: 0 to 300 psi (0 to 2500 kPa) **OR** 0 to 300 psi and 0 to 2500 kPa, **as directed**.
28. Scale Range for Steam Piping: 0 to 600 psi (0 to 4000 kPa) **OR** 0 to 600 psi and 0 to 4000 kPa, **as directed**.

H. Flowmeter Schedule
1. Flowmeters for Chilled-Water Piping: Orifice **OR** Pitot-tube **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed,** type.
2. Flowmeters for Condenser-Water Piping: Orifice **OR** Pitot-tube **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed,** type.
3. Flowmeters for Heating, Hot-Water Piping: Orifice **OR** Pitot-tube **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed,** type.
4. Flowmeters for Steam and Steam-Condensate Piping: Orifice **OR** Turbine **OR** Venturi **OR** Vortex-shedding, **as directed,** type.

I. Thermal-Energy Meter Schedule
1. Thermal-Energy Meters for Chilled-Water Piping: Impeller-turbine **OR** Ultrasonic, **as directed,** type.
2. Thermal-Energy Meters for Condenser-Water Piping: Impeller-turbine **OR** Ultrasonic, **as directed,** type.
3. Thermal-Energy Meters for Heating, Hot-Water Piping: Impeller-turbine **OR** Ultrasonic, **as directed,** type.
4. Thermal-Energy Meters for Steam and Steam-Condensate Piping: Impeller-turbine **OR** Ultrasonic, **as directed,** type.

END OF SECTION 15080a

Task	Specification	Specification Description
15080	02242	Piped Utilities Basic Materials And Methods
15080	02455a	Water Distribution
15080	15061	Common Work Results for Fire Suppression
15080	15061a	Common Work Results for Plumbing
15080	15061b	Common Work Results for HVAC
15080	15061f	Hydronic Piping
15080	15061g	Steam And Condensate Piping
15082	02242	Piped Utilities Basic Materials And Methods
15082	15061	Common Work Results for Fire Suppression
15082	15061a	Common Work Results for Plumbing
15082	15061b	Common Work Results for HVAC

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SECTION 15083 - HYDRONIC PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hydronic pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Close-coupled, in-line centrifugal pumps.
b. Close-coupled, end-suction centrifugal pumps.
c. Separately coupled, horizontal, in-line centrifugal pumps.
d. Separately coupled, vertical, in-line centrifugal pumps.
e. Separately coupled, base-mounted, end-suction centrifugal pumps.
f. Separately coupled, base-mounted, double-suction centrifugal pumps.
g. Separately coupled, vertical-mounted, double-suction centrifugal pumps.
h. Separately coupled, vertical-mounted, turbine centrifugal pumps.
i. Automatic condensate pump units.

C. Definitions
1. Buna-N: Nitrile rubber.
2. EPT: Ethylene propylene terpolymer.

D. Submittals
1. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
2. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
a. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

F. Delivery, Storage, And Handling
1. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store pumps in dry location.
3. Retain protective covers for flanges and protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with pump manufacturer's written rigging instructions.

1.2 PRODUCTS

A. Close-Coupled, In-Line Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
   a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** union end, **as directed**, connections.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
   c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel**, as directed**.
   d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
   e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
   f. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
3. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; and rigidly mounted to pump casing. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

B. Close-Coupled, End-Suction Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa), **as directed**, minimum working pressure and a continuous water temperature of 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
   a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** flanged, **as directed**, connections.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
   c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
   d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
   e. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
   f. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; rigidly mounted to pump casing with integral pump support. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

C. Separately Coupled, Horizontal, In-Line Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa), **as**

directed, minimum working pressure and a continuous water temperature of 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.

2. Pump Construction:
   a. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** union end, **as directed**, connections.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
   c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
   d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
   e. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
3. Shaft Coupling: Molded rubber insert with interlocking spider **OR** Interlocking frame with interconnecting springs, **as directed**, capable of absorbing vibration.
4. Motor: Single speed, with permanently lubricated ball **OR** oil-lubricated sleeve, **as directed**, bearings, unless otherwise indicated; and resiliently **OR** rigidly, **as directed**, mounted to pump casing. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

D. Separately Coupled, Vertical, In-Line Centrifugal Pumps
1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
   a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, and threaded companion-flange **OR** union end, **as directed**, connections.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
   c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.
   d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket. Include water slinger on shaft between motor and seal.
   e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
   f. Pump Bearings: Permanently lubricated ball bearings **OR** Oil lubricated; bronze-journal or thrust type, **as directed**.
3. Shaft Coupling: Axially split spacer coupling.
4. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; rigidly mounted to pump casing with lifting eye and supporting lugs in motor enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

E. Separately Coupled, Base-Mounted, End-Suction Centrifugal Pumps
1. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
   a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange **OR** flanged, **as directed**, connections. Provide integral mount

on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft, **as directed**.

b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.

c. Pump Shaft: Steel, with copper-alloy shaft sleeve **OR** Stainless steel, **as directed**.

d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket.

e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

f. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

3. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor **OR** EPDM coupling sleeve for variable-speed applications, **as directed**.

4. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

5. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

6. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

F. Separately Coupled, Base-Mounted, Double-Suction Centrifugal Pumps

1. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.

2. Pump Construction:

a. Casing: Radially **OR** Horizontally, **as directed**, split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, Class 125 **OR** 250, **as directed**, flanges. Casing supports shall allow removal and replacement of impeller without disconnecting piping, **as directed**.

b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.

c. Pump Shaft: Stainless steel.

d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket.

e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

f. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.

3. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor **OR** EPDM coupling sleeve for variable-speed applications, **as directed**.

4. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

5. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

6. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

G. Separately Coupled, Vertical-Mounted, Double-Suction Centrifugal Pumps
1. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa) **OR** 250-psig (1720-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C) **OR** 225 deg F (107 deg C) **OR** 250 deg F (121 deg C), **as directed**.
2. Pump Construction:
   a. Casing: Radially split, cast iron, with replaceable bronze wear rings, **as directed**, threaded gage tappings at inlet and outlet, drain plug at bottom of volute, mounting support, and ASME B16.1, Class 125 **OR** 250, **as directed**, flanges.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
   c. Pump Shaft: Stainless steel.
   d. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N **OR** EPT, **as directed**, bellows and gasket.
   e. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
   f. Pump Bearings: Grease-lubricated ball bearings contained in cast-iron housing with grease fittings.
3. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration.
4. Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to casing. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

H. Separately Coupled, Vertical-Mounted, Turbine Centrifugal Pumps
1. Description: Factory-assembled and -tested, single-stage **OR** multistage, **as directed**, centrifugal, impeller-between-bearings, end-suction pump as defined in HI 2.1-2.2 and HI 2.3; designed for installation with pump and motor shafts mounted vertically and projecting into a sump. Rate pump for 125-psig (860-kPa) **OR** 175-psig (1204-kPa), **as directed**, minimum working pressure and a continuous water temperature of 200 deg F (93 deg C).
2. Pump Construction:
   a. Pump Bowl: Cast iron, with replaceable bronze wear ring, **as directed**, cone **OR** basket, **as directed**, strainer, and suction bell. Water passages of intermediate bowls shall be coated with porcelain enamel, **as directed**.
   b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
   c. Pump Shaft: Carbon **OR** Stainless, **as directed**, steel sized per AWWA E-101.
   d. Pump Bearings: Water-lubricated bronze and rubber sleeve bearings contained in cast-iron housing.
   e. Pump Column: ASTM A 53/A 53M, Grade B steel pipe.
   f. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Seal shall be replaceable without removing the motor or disturbing the piping.
   g. Packing Seal: Stuffing box, with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
3. Shaft Coupling: Keyed with locking collets.
4. Discharge Head: ASME B16.1, Class 125 **OR** 250, **as directed**, discharge flange with threaded gage tapping. Top of discharge head shall have a registered fit to accurately locate the driver.
5. Drive Ratchet: Nonreversing ratchet.

6. Hollow Shaft Motor: Single speed, with grease-lubricated ball bearings, unless otherwise indicated; secured to discharge head. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

I. Automatic Condensate Pump Units
1. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

J. Pump Specialty Fittings
1. Suction Diffuser: Angle pattern, 175-psig (1204-kPa) **OR** 300-psig (2060-kPa), **as directed**, pressure rating, cast **OR** ductile, **as directed**,-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.
2. Triple-Duty Valve: Angle or straight pattern, 175-psig (1204-kPa) **OR** 300-psig (2060-kPa), **as directed**, pressure rating, cast **OR** ductile, **as directed**,-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.

1.3 EXECUTION

A. Concrete Bases
1. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 15 Section "Common Work Results For Hvac"
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Cast-in-place concrete materials and placement requirements are specified in Division 02.

B. Pump Installation
1. Comply with HI 1.4 **OR** HI 2.4, **as directed**.
2. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
3. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
4. Install continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of sufficient size to support pump weight. Vibration isolation devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required. Hanger and support materials are specified in Division 15 Section "Hangers And Supports For Hvac Piping And Equipment".
5. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of sufficient size to support pump weight. Vibration isolation devices are specified in Division 15 Section(s) "Vibration And Seismic Controls For Fire-suppression Piping And Equipment" AND "Vibration And Seismic Controls For Hvac Piping And Equipment". Hanger and support materials are specified in Division 15 Section(s) "Hangers And Supports For Plumbing Piping And Equipment" AND "Hangers And Supports For Hvac Piping And Equipment".

6. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
   a. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.
   b. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
7. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

C. Alignment
1. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
2. Comply with pump and coupling manufacturers' written instructions.
3. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation" **OR** HI 2.1-2.5, "Vertical Pumps for Nomenclature, Definitions, Application and Operation",**as directed**.
4. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

D. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
4. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
5. Install check valve and throttling **OR** triple-duty, **as directed**, valve on discharge side of pumps.
6. Install Y-type strainer **OR** suction diffuser, **as directed**, and shutoff valve on suction side of pumps.
7. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
8. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
9. Install check valve and gate or ball valve on each condensate pump unit discharge.
10. Install electrical connections for power, controls, and devices.
11. Ground equipment according to Division 16 Section "Grounding And Bonding".
12. Connect wiring according to Division 16 Section "Conductors And Cables".

END OF SECTION 15083

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Task	Specification	Specification Description
15083	02242	Piped Utilities Basic Materials And Methods
15083	02456b	Steam Distribution
15083	15061	Common Work Results for Fire Suppression
15083	15061a	Common Work Results for Plumbing
15083	15061b	Common Work Results for HVAC
15083	15061f	Hydronic Piping
15083	15061g	Steam And Condensate Piping
15084	02242	Piped Utilities Basic Materials And Methods
15084	02456b	Steam Distribution
15084	15061	Common Work Results for Fire Suppression
15084	15061a	Common Work Results for Plumbing
15084	15061b	Common Work Results for HVAC
15086	02242	Piped Utilities Basic Materials And Methods
15086	02455a	Water Distribution
15086	15061	Common Work Results for Fire Suppression
15086	15061a	Common Work Results for Plumbing
15086	15061b	Common Work Results for HVAC
15086	15061g	Steam And Condensate Piping
15087	02242	Piped Utilities Basic Materials And Methods
15087	15061	Common Work Results for Fire Suppression
15087	15061a	Common Work Results for Plumbing
15087	15061b	Common Work Results for HVAC
15092	02242	Piped Utilities Basic Materials And Methods
15092	15061	Common Work Results for Fire Suppression
15092	15061a	Common Work Results for Plumbing
15092	15061b	Common Work Results for HVAC
15093	15061	Common Work Results for Fire Suppression
15093	15061a	Common Work Results for Plumbing
15093	15061b	Common Work Results for HVAC

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SECTION 15094 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hangers and supports for plumbing piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Metal pipe hangers and supports.
b. Trapeze pipe hangers.
c. Fiberglass pipe hangers.
d. Metal framing systems.
e. Fiberglass strut systems.
f. Thermal-hanger shield inserts.
g. Fastener systems.
h. Pipe stands.
i. Pipe positioning systems.
j. Equipment supports.

C. Definitions
1. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

D. Performance Requirements
1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
a. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
a. Trapeze pipe hangers.
b. Metal framing systems.
c. Fiberglass strut systems.
d. Pipe stands.
e. Equipment supports.
3. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Detail fabrication and assembly of trapeze hangers.

b. Design Calculations: Calculate requirements for designing trapeze hangers.

4. Welding certificates.

F. Quality Assurance

1. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.2 PRODUCTS

A. Metal Pipe Hangers And Supports

1. Carbon-Steel Pipe Hangers and Supports:
   a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   b. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
   c. Nonmetallic Coatings: Plastic coating, jacket, or liner.
   d. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
2. Stainless-Steel Pipe Hangers and Supports:
   a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
   b. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
   c. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
3. Copper Pipe Hangers:
   a. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
   b. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel **OR** stainless steel, **as directed**.

B. Trapeze Pipe Hangers

1. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

C. Fiberglass Pipe Hangers

1. Clevis-Type, Fiberglass Pipe Hangers:
   a. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
   b. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.
2. Strap-Type, Fiberglass Pipe Hangers:
   a. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
   b. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

D. Metal Framing Systems

1. MFMA Manufacturer Metal Framing Systems:
   a. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
   b. Standard: MFMA-4.

c. Channels: Continuous slotted steel channel with inturned lips.
d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
f. Metallic Coating: Electroplated zinc **OR** Hot-dipped galvanized **OR** Mill galvanized **OR** In-line, hot galvanized **OR** Mechanically-deposited zinc, **as directed**.
OR
Paint Coating: Vinyl **OR** Vinyl alkyd **OR** Epoxy **OR** Polyester **OR** Acrylic **OR** Amine **OR** Alkyd, **as directed**.
OR
Plastic Coating: PVC **OR** Polyurethane **OR** Epoxy **OR** Polyester, **as directed**.
OR
Combination Coating: <**Insert coating materials in order of application**>.

2. Non-MFMA Manufacturer Metal Framing Systems:
a. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
b. Standard: Comply with MFMA-4.
c. Channels: Continuous slotted steel channel with inturned lips.
d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
f. Coating: Zinc **OR** Paint **OR** PVC, **as directed**.

E. Fiberglass Strut Systems
1. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
a. Channels: Continuous slotted fiberglass or other plastic channel with inturned lips.
b. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
c. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass **OR** stainless steel, **as directed**.

F. Thermal-Hanger Shield Inserts
1. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
2. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
5. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

G. Fastener Systems
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated **OR** stainless-, **as directed**, steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

H. Pipe Stands

1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
2. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
3. Low-Type, Single-Pipe Stand: One-piece plastic **OR** stainless-steel, **as directed**, base unit with plastic roller, for roof installation without membrane penetration.
4. High-Type, Single-Pipe Stand:
   a. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   b. Base: Plastic **OR** Stainless steel, **as directed**.
   c. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   d. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
5. High-Type, Multiple-Pipe Stand:
   a. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   b. Bases: One or more; plastic.
   c. Vertical Members: Two or more protective-coated-steel channels.
   d. Horizontal Member: Protective-coated-steel channel.
   e. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
6. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

I. Pipe Positioning Systems
1. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

J. Equipment Supports
1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

K. Miscellaneous Materials
1. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
2. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   a. Properties: Nonstaining, noncorrosive, and nongaseous.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

1.3 EXECUTION

A. Hanger And Support Installation
1. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
2. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   a. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.

b. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

3. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
4. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
5. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
6. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
7. Fastener System Installation:
   a. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   b. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
8. Pipe Stand Installation:
   a. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   b. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 7 Section "Roof Accessories" for curbs.
9. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 15 plumbing fixture Sections for requirements for pipe positioning systems for plumbing fixtures.
10. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
11. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
12. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
13. Install lateral bracing with pipe hangers and supports to prevent swaying.
14. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
15. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
16. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
17. Insulated Piping:
   a. Attach clamps and spacers to piping.
      1) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      2) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      3) Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   b. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
   c. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

d. Shield Dimensions for Pipe: Not less than the following:
   1) NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   2) NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   3) NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   4) NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   5) NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

e. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

f. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

B. Equipment Supports
1. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
2. Grouting: Place grout under supports for equipment and make bearing surface smooth.
3. Provide lateral bracing, to prevent swaying, for equipment supports.

C. Metal Fabrications
1. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
2. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
3. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   b. Obtain fusion without undercut or overlap.
   c. Remove welding flux immediately.
   d. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

D. Adjusting
1. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
2. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

E. Painting
1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

   OR

   Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 painting Sections **OR** Section "High-Performance Coatings", **as directed**.
2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

F. Hanger And Support Schedule
1. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
2. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
3. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
4. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
5. Use carbon-steel pipe hangers and supports**,** metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
6. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.
7. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
8. Use padded hangers for piping that is subject to scratching.
9. Use thermal-hanger shield inserts for insulated piping and tubing.
10. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
    b. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
    c. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
    d. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
    e. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
    f. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
    g. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
    h. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
    i. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
    j. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
    k. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
    l. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
    m. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
    n. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
    o. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
    p. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.

q. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
r. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
s. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
t. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
u. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

11. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
    b. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
12. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
    b. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
    c. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
    d. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
    e. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
13. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
    b. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
    c. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
    d. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
    e. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
    f. C-Clamps (MSS Type 23): For structural shapes.
    g. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
    h. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
    i. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
    j. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
    k. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
    l. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

1) Light (MSS Type 31): 750 lb (340 kg).
2) Medium (MSS Type 32): 1500 lb (680 kg).
3) Heavy (MSS Type 33): 3000 lb (1360 kg).

m. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
n. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
o. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

14. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
    b. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
    c. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
15. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
    b. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
    c. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
    d. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
    e. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
    f. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
    g. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
    h. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
        1) Horizontal (MSS Type 54): Mounted horizontally.
        2) Vertical (MSS Type 55): Mounted vertically.
        3) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
16. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
17. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
18. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
19. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 15094

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SECTION 15094a - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hangers and supports for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Metal pipe hangers and supports.
b. Trapeze pipe hangers.
c. Fiberglass pipe hangers.
d. Metal framing systems.
e. Fiberglass strut systems.
f. Thermal-hanger shield inserts.
g. Fastener systems.
h. Pipe stands.
i. Equipment supports.

C. Definitions
1. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

D. Performance Requirements
1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
a. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
a. Trapeze pipe hangers.
b. Metal framing systems.
c. Fiberglass strut systems.
d. Pipe stands.
e. Equipment supports.
3. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Detail fabrication and assembly of trapeze hangers.
b. Design Calculations: Calculate requirements for designing trapeze hangers.

4. Welding certificates.

F. Quality Assurance
1. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

1.2 PRODUCTS

A. Metal Pipe Hangers And Supports
1. Carbon-Steel Pipe Hangers and Supports:
a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
b. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
c. Nonmetallic Coatings: Plastic coating, jacket, or liner.
d. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
2. Stainless-Steel Pipe Hangers and Supports:
a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
b. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
c. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
3. Copper Pipe Hangers:
a. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
b. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel **OR** stainless steel, **as directed**.

B. Trapeze Pipe Hangers
1. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

C. Fiberglass Pipe Hangers
1. Clevis-Type, Fiberglass Pipe Hangers:
a. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
b. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.
2. Strap-Type, Fiberglass Pipe Hangers:
a. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
b. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

D. Metal Framing Systems
1. MFMA Manufacturer Metal Framing Systems:
a. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
b. Standard: MFMA-4.
c. Channels: Continuous slotted steel channel with inturned lips.

d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
f. Metallic Coating: Electroplated zinc **OR** Hot-dipped galvanized **OR** Mill galvanized **OR** In-line, hot galvanized **OR** Mechanically-deposited zinc, **as directed**.
OR
Paint Coating: Vinyl **OR** Vinyl alkyd **OR** Epoxy **OR** Polyester **OR** Acrylic **OR** Amine **OR** Alkyd, **as directed**.
OR
Plastic Coating: PVC **OR** Polyurethane **OR** Epoxy **OR** Polyester, **as directed**.
OR
Combination Coating: as directed by the Owner.

2. Non-MFMA Manufacturer Metal Framing Systems:
a. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
b. Standard: Comply with MFMA-4.
c. Channels: Continuous slotted steel channel with inturned lips.
d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
f. Coating: Zinc **OR** Paint **OR** PVC, **as directed**.

E. Fiberglass Strut Systems
1. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
a. Channels: Continuous slotted fiberglass or other plastic channel with inturned lips.
b. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
c. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass **OR** stainless steel, **as directed**.

F. Thermal-Hanger Shield Inserts
1. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
2. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
5. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

G. Fastener Systems
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated **OR** stainless-, **as directed**, steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

H. Pipe Stands

1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
2. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
3. Low-Type, Single-Pipe Stand: One-piece plastic **OR** stainless-steel, **as directed**, base unit with plastic roller, for roof installation without membrane penetration.
4. High-Type, Single-Pipe Stand:
   a. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
   b. Base: Plastic **OR** Stainless steel, **as directed**.
   c. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
   d. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
5. High-Type, Multiple-Pipe Stand:
   a. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
   b. Bases: One or more; plastic.
   c. Vertical Members: Two or more protective-coated-steel channels.
   d. Horizontal Member: Protective-coated-steel channel.
   e. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
6. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

I. Equipment Supports
1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

J. Miscellaneous Materials
1. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
2. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
   a. Properties: Nonstaining, noncorrosive, and nongaseous.
   b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

1.3 EXECUTION

A. Hanger And Support Installation
1. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
2. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
   a. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
   b. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
3. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

4. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
5. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
6. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
7. Fastener System Installation:
   a. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   b. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
8. Pipe Stand Installation:
   a. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   b. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
9. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
10. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
11. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
12. Install lateral bracing with pipe hangers and supports to prevent swaying.
13. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
14. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
15. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
16. Insulated Piping:
   a. Attach clamps and spacers to piping.
      1) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      2) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      3) Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   b. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
   c. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
   d. Shield Dimensions for Pipe: Not less than the following:
      1) NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
      2) NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
      3) NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.

4) NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
5) NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

e. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.

f. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

B. Equipment Supports

1. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
2. Grouting: Place grout under supports for equipment and make bearing surface smooth.
3. Provide lateral bracing, to prevent swaying, for equipment supports.

C. Metal Fabrications

1. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
2. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
3. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
   a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   b. Obtain fusion without undercut or overlap.
   c. Remove welding flux immediately.
   d. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

D. Adjusting

1. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
2. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

E. Painting

1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

   OR

   Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings", **as directed**.
2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

F. Hanger And Support Schedule

1. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
2. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
3. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.

4. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
5. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
6. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.
7. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
8. Use padded hangers for piping that is subject to scratching.
9. Use thermal-hanger shield inserts for insulated piping and tubing.
10. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
    b. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C),pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
    c. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
    d. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
    e. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
    f. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
    g. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
    h. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
    i. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
    j. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
    k. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
    l. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
    m. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
    n. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
    o. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
    p. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
    q. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
    r. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.

s. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
t. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
u. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

11. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
    b. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
12. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
    b. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
    c. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
    d. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
    e. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
13. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
    b. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
    c. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
    d. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
    e. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
    f. C-Clamps (MSS Type 23): For structural shapes.
    g. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
    h. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
    i. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
    j. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
    k. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
    l. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
        1) Light (MSS Type 31): 750 lb (340 kg).
        2) Medium (MSS Type 32): 1500 lb (680 kg).
        3) Heavy (MSS Type 33): 3000 lb (1360 kg).
    m. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
    n. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
    o. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

14. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
    b. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
    c. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
15. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
    a. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
    b. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
    c. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
    d. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
    e. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
    f. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
    g. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
    h. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
        1) Horizontal (MSS Type 54): Mounted horizontally.
        2) Vertical (MSS Type 55): Mounted vertically.
        3) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
16. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
17. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
18. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 15094a

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Task	Specification	Specification Description
15094	02242	Piped Utilities Basic Materials And Methods
15094	15061	Common Work Results for Fire Suppression
15094	15061a	Common Work Results for Plumbing
15094	15061b	Common Work Results for HVAC

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SECTION 15101 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of general-duty valves for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Bronze angle valves.
b. Brass ball valves.
c. Bronze ball valves.
d. Iron ball valves.
e. Iron, single-flange butterfly valves.
f. Iron, grooved-end butterfly valves.
g. Bronze lift check valves.
h. Bronze swing check valves.
i. Iron swing check valves.
j. Iron swing check valves with closure control.
k. Iron, grooved-end swing check valves.
l. Iron, center-guided check valves.
m. Iron, plate-type check valves.
n. Bronze gate valves.
o. Iron gate valves.
p. Bronze globe valves.
q. Iron globe valves.
r. Lubricated plug valves.
s. Chainwheels.

C. Definitions
1. CWP: Cold working pressure.
2. EPDM: Ethylene propylene copolymer rubber.
3. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
4. NRS: Nonrising stem.
5. OS&Y: Outside screw and yoke.
6. RS: Rising stem.
7. SWP: Steam working pressure.

D. Submittals
1. Product Data: For each type of valve indicated.

E. Quality Assurance
1. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
2. ASME Compliance:
a. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
b. ASME B31.1 for power piping valves.
c. ASME B31.9 for building services piping valves.
3. NSF Compliance: NSF 61 for valve materials for potable-water service.

F. Delivery, Storage, And Handling

1. Prepare valves for shipping as follows:
   a. Protect internal parts against rust and corrosion.
   b. Protect threads, flange faces, grooves, and weld ends.
   c. Set angle, gate, and globe valves closed to prevent rattling.
   d. Set ball and plug valves open to minimize exposure of functional surfaces.
   e. Set butterfly valves closed or slightly open.
   f. Block check valves in either closed or open position.
2. Use the following precautions during storage:
   a. Maintain valve end protection.
   b. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.2 PRODUCTS

A. General Requirements For Valves
1. Refer to valve schedule articles for applications of valves.
2. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
3. Valve Sizes: Same as upstream piping unless otherwise indicated.
4. Valve Actuator Types:
   a. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
   b. Handwheel: For valves other than quarter-turn types.
   c. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves, **as directed**.
   d. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 **OR** 10, **as directed**, plug valves, for each size square plug-valve head.
   e. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
5. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
   a. Gate Valves: With rising stem.
   b. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   c. Butterfly Valves: With extended neck.
6. Valve-End Connections:
   a. Flanged: With flanges according to ASME B16.1 for iron valves.
   b. Grooved: With grooves according to AWWA C606.
   c. Solder Joint: With sockets according to ASME B16.18.
   d. Threaded: With threads according to ASME B1.20.1.
7. Valve Bypass and Drain Connections: MSS SP-45.

B. Bronze Angle Valves
1. Class 125, Bronze Angle Valves with Bronze Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 1.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      4) Ends: Threaded.
      5) Stem and Disc: Bronze.
      6) Packing: Asbestos free.
      7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, Bronze Angle Valves with Nonmetallic Disc:

a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: PTFE or TFE.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

3. Class 150, Bronze Angle Valves with Bronze Disc:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem and Disc: Bronze.
6) Packing: Asbestos free.
7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

4. Class 150, Bronze Angle Valves with Nonmetallic Disc:
a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: PTFE or TFE.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

C. Brass Ball Valves
1. One-Piece, Reduced-Port, Brass Ball Valves with Brass Trim:
a. Description:
1) Standard: MSS SP-110.
2) CWP Rating: 400 psig (2760 kPa).
3) Body Design: One piece.
4) Body Material: Forged brass.
5) Ends: Threaded.
6) Seats: PTFE or TFE.
7) Stem: Brass.
8) Ball: Chrome-plated brass.
9) Port: Reduced.

2. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Forged brass.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Brass.
9) Ball: Chrome-plated brass.
10) Port: Full.

3. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
a. Description:
1) Standard: MSS SP-110.

2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Forged brass.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Stainless steel.
9) Ball: Stainless steel, vented.
10) Port: Full.

4. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Brass.
      9) Ball: Chrome-plated brass.
      10) Port: Regular.
5. Two-Piece, Regular-Port, Brass Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Brass or bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.
      9) Ball: Stainless steel, vented.
      10) Port: Regular.
6. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Brass.
      9) Ball: Chrome-plated brass.
      10) Port: Full.
7. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.

9) Ball: Stainless steel, vented.
10) Port: Full.

D. Bronze Ball Valves
1. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:
a. Description:
1) Standard: MSS SP-110.
2) CWP Rating: 400 psig (2760 kPa).
3) Body Design: One piece.
4) Body Material: Bronze.
5) Ends: Threaded.
6) Seats: PTFE or TFE.
7) Stem: Bronze.
8) Ball: Chrome-plated brass.
9) Port: Reduced.
2. One-Piece, Reduced-Port, Bronze Ball Valves with Stainless-Steel Trim:
a. Description:
1) Standard: MSS SP-110.
2) CWP Rating: 600 psig (4140 kPa).
3) Body Design: One piece.
4) Body Material: Bronze.
5) Ends: Threaded.
6) Seats: PTFE or TFE.
7) Stem: Stainless steel.
8) Ball: Stainless steel, vented.
9) Port: Reduced.
3. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Bronze.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Bronze.
9) Ball: Chrome-plated brass.
10) Port: Full.
4. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Bronze.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Stainless steel.
9) Ball: Stainless steel, vented.
10) Port: Full.
5. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.

5) Body Material: Bronze.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Bronze.
9) Ball: Chrome-plated brass.
10) Port: Regular.

6. Two-Piece, Regular-Port, Bronze Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.
      9) Ball: Stainless steel, vented.
      10) Port: Regular.
7. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Bronze.
      9) Ball: Chrome-plated brass.
      10) Port: Full.
8. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.
      9) Ball: Stainless steel, vented.
      10) Port: Full.

E. Iron Ball Valves
1. Class 125, Iron Ball Valves:
   a. Description:
      1) Standard: MSS SP-72.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Split body.
      4) Body Material: ASTM A 126, gray iron.
      5) Ends: Flanged.
      6) Seats: PTFE or TFE.
      7) Stem: Stainless steel.
      8) Ball: Stainless steel.
      9) Port: Full.

F. Iron, Single-Flange Butterfly Valves
1. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: EPDM.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Aluminum bronze.
2. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: NBR.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Aluminum bronze.
3. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: EPDM.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
4. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: NBR.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
5. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: EPDM.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Stainless steel.
6. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).

3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: NBR.
6) Stem: One- or two-piece stainless steel.
7) Disc: Stainless steel.

G. Iron, Grooved-End Butterfly Valves
1. 175 CWP, Iron, Grooved-End Butterfly Valves:
a. Description:
1) Standard: MSS SP-67, Type I.
2) CWP Rating: 175 psig (1200 kPa).
3) Body Material: Coated, ductile iron.
4) Stem: Two-piece stainless steel.
5) Disc: Coated, ductile iron.
6) Seal: EPDM.
2. 300 CWP, Iron, Grooved-End Butterfly Valves:
a. Description:
1) Standard: MSS SP-67, Type I.
2) NPS 8 (DN 200) and Smaller CWP Rating: 300 psig (2070 kPa).
3) NPS 10 (DN 250) and Larger CWP Rating: 200 psig (1380 kPa).
4) Body Material: Coated, ductile iron.
5) Stem: Two-piece stainless steel.
6) Disc: Coated, ductile iron.
7) Seal: EPDM.

H. Bronze Lift Check Valves
1. Class 125, Lift Check Valves with Bronze Disc:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Design: Vertical flow.
4) Body Material: ASTM B 61 or ASTM B 62, bronze.
5) Ends: Threaded.
6) Disc: Bronze.
2. Class 125, Lift Check Valves with Nonmetallic Disc:
a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Design: Vertical flow.
4) Body Material: ASTM B 61 or ASTM B 62, bronze.
5) Ends: Threaded.
6) Disc: NBR, PTFE, or TFE.

I. Bronze Swing Check Valves
1. Class 125, Bronze Swing Check Valves with Bronze Disc:
a. Description:
1) Standard: MSS SP-80, Type 3.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Design: Horizontal flow.
4) Body Material: ASTM B 62, bronze.
5) Ends: Threaded.
6) Disc: Bronze.
2. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
a. Description:

1) Standard: MSS SP-80, Type 4.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Design: Horizontal flow.
4) Body Material: ASTM B 62, bronze.
5) Ends: Threaded.
6) Disc: PTFE or TFE.

3. Class 150, Bronze Swing Check Valves with Bronze Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 3.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Design: Horizontal flow.
      4) Body Material: ASTM B 62, bronze.
      5) Ends: Threaded.
      6) Disc: Bronze.
4. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 4.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Design: Horizontal flow.
      4) Body Material: ASTM B 62, bronze.
      5) Ends: Threaded.
      6) Disc: PTFE or TFE.

J. Iron Swing Check Valves
1. Class 125, Iron Swing Check Valves with Metal Seats:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Clear or full waterway.
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Gasket: Asbestos free.
2. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Clear or full waterway.
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Composition.
      7) Seat Ring: Bronze.
      8) Disc Holder: Bronze.
      9) Disc: PTFE or TFE.
      10) Gasket: Asbestos free.
3. Class 250, Iron Swing Check Valves with Metal Seats:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Design: Clear or full waterway.
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Gasket: Asbestos free.

K. Iron Swing Check Valves With Closure Control

1. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Clear or full waterway.
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Gasket: Asbestos free.
      8) Closure Control: Factory-installed, exterior lever and spring.
2. Class 125, Iron Swing Check Valves with Lever- and Weight-Closure Control:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Clear or full waterway.
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Gasket: Asbestos free.
      8) Closure Control: Factory-installed, exterior lever and weight.

L. Iron, Grooved-End Swing Check Valves
1. 300 CWP, Iron, Grooved-End Swing Check Valves:
   a. Description:
      1) CWP Rating: 300 psig (2070 kPa).
      2) Body Material: ASTM A 536, ductile iron.
      3) Seal: EPDM.
      4) Disc: Spring-operated, ductile iron or stainless steel.

M. Iron, Center-Guided Check Valves
1. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM A 126, gray iron.
      4) Style: Compact wafer.
      5) Seat: Bronze.
2. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM A 126, gray iron.
      4) Style: Globe, spring loaded.
      5) Ends: Flanged.
      6) Seat: Bronze.
3. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      4) Style: Compact wafer.
      5) Seat: Bronze.
4. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.

2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
4) Style: Globe, spring loaded.
5) Ends: Flanged.
6) Seat: Bronze.

5. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Material: ASTM A 126, gray iron.
      4) Style: Compact wafer, spring loaded.
      5) Seat: Bronze.
6. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Material: ASTM A 126, gray iron.
      4) Style: Globe, spring loaded.
      5) Ends: Flanged.
      6) Seat: Bronze.
7. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      4) Style: Compact wafer, spring loaded.
      5) Seat: Bronze.
8. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      4) Style: Globe, spring loaded.
      5) Ends: Flanged.
      6) Seat: Bronze.
9. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM A 126, gray iron.
      4) Style: Compact wafer.
      5) Seat: EPDM **OR** NBR, **as directed**.
10. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
    a. Description:
       1) Standard: MSS SP-125.
       2) CWP Rating: 200 psig (1380 kPa).
       3) Body Material: ASTM A 126, gray iron.
       4) Style: Globe, spring loaded.
       5) Ends: Flanged.
       6) Seat: EPDM **OR** NBR, **as directed**.
11. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
    a. Description:
       1) Standard: MSS SP-125.
       2) CWP Rating: 300 psig (2070 kPa).
       3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
       4) Style: Compact wafer.

5) Seat: EPDM **OR** NBR, **as directed**.

12. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) CWP Rating: 300 psig (2070 kPa).
        3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        4) Style: Globe, spring loaded.
        5) Ends: Flanged.
        6) Seat: EPDM **OR** NBR, **as directed**.
13. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) CWP Rating: 400 psig (2760 kPa).
        3) Body Material: ASTM A 126, gray iron.
        4) Style: Compact wafer, spring loaded.
        5) Seat: EPDM **OR** NBR, **as directed**.
14. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) CWP Rating: 400 psig (2760 kPa).
        3) Body Material: ASTM A 126, gray iron.
        4) Style: Globe, spring loaded.
        5) Ends: Flanged.
        6) Seat: EPDM **OR** NBR, **as directed**.
15. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) CWP Rating: 500 psig (3450 kPa).
        3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        4) Style: Compact wafer, spring loaded.
        5) Seat: EPDM **OR** NBR, **as directed**.
16. Class 300, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) CWP Rating: 500 psig (3450 kPa).
        3) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        4) Style: Globe, spring loaded.
        5) Ends: Flanged.
        6) Seat: EPDM **OR** NBR, **as directed**.

N. Iron, Plate-Type Check Valves
1. Class 125, Iron, Dual-Plate Check Valves with Metal Seat:
    a. Description:
        1) Standard: API 594.
        2) CWP Rating: 200 psig (1380 kPa).
        3) Body Design: Wafer, spring-loaded plates.
        4) Body Material: ASTM A 126, gray iron.
        5) Seat: Bronze.
2. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:
    a. Description:
        1) Standard: API 594.
        2) CWP Rating: 300 psig (2070 kPa).
        3) Body Design: Wafer, spring-loaded plates.
        4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        5) Seat: Bronze.

3. Class 250, Iron, Dual-Plate Check Valves with Metal Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Design: Wafer, spring-loaded plates.
      4) Body Material: ASTM A 126, gray iron.
      5) Seat: Bronze.
4. Class 300, Iron, Dual-Plate Check Valves with Metal Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Design: Wafer, spring-loaded plates.
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Seat: Bronze.
5. Class 125, Iron, Single-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Wafer, spring-loaded plate.
      4) Body Material: ASTM A 126, gray iron.
      5) Seat: EPDM **OR** NBR, **as directed**.
6. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Wafer, spring-loaded plates.
      4) Body Material: ASTM A 126, gray iron.
      5) Seat: EPDM **OR** NBR, **as directed**.
7. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Design: Wafer, spring-loaded plates.
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Seat: EPDM **OR** NBR, **as directed**.
8. Class 250, Iron, Wafer, Single-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Design: Wafer, spring-loaded plate.
      4) Body Material: ASTM A 126, gray iron.
      5) Seat: EPDM **OR** NBR, **as directed**.
9. Class 250, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Design: Wafer, spring-loaded plates.
      4) Body Material: ASTM A 126, gray iron.
      5) Seat: EPDM **OR** NBR, **as directed**.
10. Class 300, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Design: Wafer, spring-loaded plates.
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Seat: EPDM **OR** NBR, **as directed**.

O. Bronze Gate Valves
1. Class 125, NRS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
4) Ends: Threaded or solder joint, **as directed**.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, RS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
4) Ends: Threaded or solder joint, **as directed**.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, NRS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
4. Class 150, RS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

P. Iron Gate Valves
1. Class 125, NRS, Iron Gate Valves:
a. Description:
1) Standard: MSS SP-70, Type I.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 126, gray iron with bolted bonnet.
4) Ends: Flanged.
5) Trim: Bronze.
6) Disc: Solid wedge.
7) Packing and Gasket: Asbestos free.
2. Class 125, OS&Y, Iron Gate Valves:
a. Description:
1) Standard: MSS SP-70, Type I.

2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 126, gray iron with bolted bonnet.
4) Ends: Flanged.
5) Trim: Bronze.
6) Disc: Solid wedge.
7) Packing and Gasket: Asbestos free.

3. Class 250, NRS, Iron Gate Valves:
   a. Description:
      1) Standard: MSS SP-70, Type I.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Material: ASTM A 126, gray iron with bolted bonnet.
      4) Ends: Flanged.
      5) Trim: Bronze.
      6) Disc: Solid wedge.
      7) Packing and Gasket: Asbestos free.
4. Class 250, OS&Y, Iron Gate Valves:
   a. Description:
      1) Standard: MSS SP-70, Type I.
      2) CWP Rating: 500 psig (3450 kPa).
      3) Body Material: ASTM A 126, gray iron with bolted bonnet.
      4) Ends: Flanged.
      5) Trim: Bronze.
      6) Disc: Solid wedge.
      7) Packing and Gasket: Asbestos free.

Q. Bronze Globe Valves
1. Class 125, Bronze Globe Valves with Bronze Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 1.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      4) Ends: Threaded or solder joint, **as directed**.
      5) Stem and Disc: Bronze.
      6) Packing: Asbestos free.
      7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, Bronze Globe Valves with Nonmetallic Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 2.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      4) Ends: Threaded or solder joint, **as directed**.
      5) Stem: Bronze.
      6) Disc: PTFE or TFE.
      7) Packing: Asbestos free.
      8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, Bronze Globe Valves with Nonmetallic Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 2.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      4) Ends: Threaded.
      5) Stem: Bronze.
      6) Disc: PTFE or TFE.
      7) Packing: Asbestos free.
      8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

R. Iron Globe Valves
1. Class 125, Iron Globe Valves:
a. Description:
1) Standard: MSS SP-85, Type I.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 126, gray iron with bolted bonnet.
4) Ends: Flanged.
5) Trim: Bronze.
6) Packing and Gasket: Asbestos free.
2. Class 250, Iron Globe Valves:
a. Description:
1) Standard: MSS SP-85, Type I.
2) CWP Rating: 500 psig (3450 kPa).
3) Body Material: ASTM A 126, gray iron with bolted bonnet.
4) Ends: Flanged.
5) Trim: Bronze.
6) Packing and Gasket: Asbestos free.

S. Lubricated Plug Valves
1. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
a. Description:
1) Standard: MSS SP-78, Type II.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
4) Pattern: Regular or short **OR** Venturi, **as directed**.
5) Plug: Cast iron or bronze with sealant groove.
2. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
a. Description:
1) Standard: MSS SP-78, Type II.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
4) Pattern: Regular or short **OR** Venturi, **as directed**.
5) Plug: Cast iron or bronze with sealant groove.
3. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
a. Description:
1) Standard: MSS SP-78, Type IV.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
4) Pattern: Regular or short **OR** Venturi, **as directed**.
5) Plug: Cast iron or bronze with sealant groove.
4. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
a. Description:
1) Standard: MSS SP-78, Type IV.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
4) Pattern: Regular or short **OR** Venturi, **as directed**.
5) Plug: Cast iron or bronze with sealant groove.
5. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
a. Description:
1) Standard: MSS SP-78, Type II.
2) CWP Rating: 400 psig (2760 kPa).

3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
4) Pattern: Regular or short **OR** Venturi, **as directed**.
5) Plug: Cast iron or bronze with sealant groove.

6. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
   a. Description:
      1) Standard: MSS SP-78, Type II.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      4) Pattern: Regular or short **OR** Venturi, **as directed**.
      5) Plug: Cast iron or bronze with sealant groove.
7. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
   a. Description:
      1) Standard: MSS SP-78, Type IV.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      4) Pattern: Regular or short **OR** Venturi, **as directed**.
      5) Plug: Cast iron or bronze with sealant groove.
8. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:
   a. Description:
      1) Standard: MSS SP-78, Type IV.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
      4) Pattern: Regular or short **OR** Venturi, **as directed**.
      5) Plug: Cast iron or bronze with sealant groove.

T. Chainwheels
1. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
   a. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
   b. Attachment: For connection to ball **OR** butterfly **OR** plug, **as directed**, valve stems.
   c. Sprocket Rim with Chain Guides: Ductile iron **OR** Cast iron **OR** Aluminum **OR** Bronze, **as directed**, of type and size required for valve. Include zinc coating, **as directed**.
   d. Chain: Hot-dip, galvanized steel **OR** Brass **OR** Stainless steel, **as directed**, of size required to fit sprocket rim.

1.3 EXECUTION

A. Valve Installation
1. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
2. Locate valves for easy access and provide separate support where necessary.
3. Install valves in horizontal piping with stem at or above center of pipe.
4. Install valves in position to allow full stem movement.
5. Install chainwheels on operators for ball **OR** butterfly **OR** gate **OR** globe **OR** plug, **as directed**, valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
6. Install check valves for proper direction of flow and as follows:
   a. Swing Check Valves: In horizontal position with hinge pin level.
   b. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
   c. Lift Check Valves: With stem upright and plumb.

B. Adjusting
   1. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

C. General Requirements For Valve Applications
   1. If valve applications are not indicated, use the following:
      a. Shutoff Service: Ball **OR** butterfly **OR** gate **OR** plug, **as directed**, valves.
      b. Butterfly Valve Dead-End Service: Single-flange (lug) type.
      c. Throttling Service: Globe **OR** angle **OR** ball **OR** butterfly, **as directed**, valves.
      d. Pump-Discharge Check Valves:
         1) NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze **OR** nonmetallic, **as directed**, disc.
         2) NPS 2-1/2 (DN 65) and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal **OR** resilient, **as directed**,-seat check valves.
         3) NPS 2-1/2 (DN 65) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
   2. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
   3. Select valves, except wafer types, with the following end connections:
      a. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
      b. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
      c. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
      d. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
      e. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
      f. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
      g. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

D. Low-Pressure, Compressed-Air Valve Schedule (150 psig (1035 kPa) Or Less)
   1. Pipe NPS 2 (DN 50) and Smaller:
      a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
      b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
      c. Bronze Lift Check Valves: Class 125, bronze **OR** nonmetallic, **as directed**, disc.
      d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
      e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
   2. Pipe NPS 2-1/2 (DN 65) and Larger:
      a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
      b. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
      c. Iron, Grooved-End Butterfly Valves: 175 **OR** 300, **as directed**, CWP.
      d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
      e. Iron, Grooved-End Swing Check Valves: 300 CWP.
      f. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
      g. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.

h. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**,.

E. High-Pressure, Compressed-Air Valve Schedule (150 to 200 psig (1035 to 1380 kPa))

1. Pipe NPS 2 (DN 50) and Smaller:
   a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
   b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
   c. Bronze Lift Check Valves: Class 125, bronze **OR** nonmetallic, **as directed**, disc.
   d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
   e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
   a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
   b. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
   c. Iron, Grooved-End Butterfly Valves: 175 **OR** 300, **as directed**, CWP.
   d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
   e. Iron, Grooved-End Swing Check Valves: 300 CWP.
   f. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
   g. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
   h. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.

F. Domestic, Hot- And Cold-Water Valve Schedule

1. Pipe NPS 2 (DN 50) and Smaller:
   a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
   b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
   c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
   d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
   e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**,.
   f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
   a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
   b. Iron Ball Valves: Class 150.
   c. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
   d. Iron, Grooved-End Butterfly Valves: 175 **OR** 300, **as directed**, CWP.
   e. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
   f. Iron Swing Check Valves with Closure Control: Class 125, lever and spring **OR** weight, **as directed**.
   g. Iron, Grooved-End Swing Check Valves: 300 CWP.
   h. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.

i. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
j. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
k. Iron Globe Valves: Class 125 **OR** Class 250, **as directed**.

G. Sanitary-Waste And Storm-Drainage Valve Schedule
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic **OR** stainless-steel, **as directed**, disc.
c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Iron Ball Valves: Class 150.
c. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
d. Iron Swing Check Valves with Closure Control: Class 125, lever and spring **OR** weight, **as directed**.
e. Iron, Grooved-End Swing Check Valves: 300 CWP.
f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
g. Iron Globe Valves: Class 125 **OR** Class 250, **as directed**.
h. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.

END OF SECTION 15101

SECTION 15101a - GENERAL-DUTY VALVES FOR HVAC PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of general-duty valves for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Bronze angle valves.
b. Brass ball valves.
c. Bronze ball valves.
d. Iron ball valves.
e. Iron, single-flange butterfly valves.
f. Iron, grooved-end butterfly valves.
g. High-performance butterfly valves.
h. Bronze lift check valves.
i. Bronze swing check valves.
j. Iron swing check valves.
k. Iron swing check valves with closure control.
l. Iron, grooved-end swing-check valves.
m. Iron, center-guided check valves.
n. Iron, plate-type check valves.
o. Bronze gate valves.
p. Iron gate valves.
q. Bronze globe valves.
r. Iron globe valves.
s. Lubricated plug valves.
t. Eccentric plug valves.
u. Chainwheels.

C. Definitions
1. CWP: Cold working pressure.
2. EPDM: Ethylene propylene copolymer rubber.
3. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
4. NRS: Nonrising stem.
5. OS&Y: Outside screw and yoke.
6. RS: Rising stem.
7. SWP: Steam working pressure.

D. Submittals
1. Product Data: For each type of valve indicated.

E. Quality Assurance
1. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
2. ASME Compliance:
a. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
b. ASME B31.1 for power piping valves.
c. ASME B31.9 for building services piping valves.

F. Delivery, Storage, And Handling
1. Prepare valves for shipping as follows:
a. Protect internal parts against rust and corrosion.
b. Protect threads, flange faces, grooves, and weld ends.
c. Set angle, gate, and globe valves closed to prevent rattling.
d. Set ball and plug valves open to minimize exposure of functional surfaces.
e. Set butterfly valves closed or slightly open.
f. Block check valves in either closed or open position.
2. Use the following precautions during storage:
a. Maintain valve end protection.
b. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
3. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

1.2 PRODUCTS

A. General Requirements For Valves
1. Refer to HVAC valve schedule articles for applications of valves.
2. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
3. Valve Sizes: Same as upstream piping unless otherwise indicated.
4. Valve Actuator Types:
a. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
b. Handwheel: For valves other than quarter-turn types.
c. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller except plug valves, **as directed**.
d. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 **OR** 10, **as directed**, plug valves, for each size square plug-valve head.
e. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
5. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
a. Gate Valves: With rising stem.
b. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
c. Butterfly Valves: With extended neck.
6. Valve-End Connections:
a. Flanged: With flanges according to ASME B16.1 for iron valves.
b. Grooved: With grooves according to AWWA C606.
c. Solder Joint: With sockets according to ASME B16.18.
d. Threaded: With threads according to ASME B1.20.1.
7. Valve Bypass and Drain Connections: MSS SP-45.

B. Bronze Angle Valves
1. Class 125, Bronze Angle Valves with Bronze Disc:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
4) Ends: Threaded.
5) Stem and Disc: Bronze.
6) Packing: Asbestos free.
7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

2. Class 125, Bronze Angle Valves with Nonmetallic Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 2.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      4) Ends: Threaded.
      5) Stem: Bronze.
      6) Disc: PTFE or TFE.
      7) Packing: Asbestos free.
      8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, Bronze Angle Valves with Bronze Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 1.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      4) Ends: Threaded.
      5) Stem and Disc: Bronze.
      6) Packing: Asbestos free.
      7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
4. Class 150, Bronze Angle Valves with Nonmetallic Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 2.
      2) CWP Rating: 300 psig (2070 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
      4) Ends: Threaded.
      5) Stem: Bronze.
      6) Disc: PTFE or TFE.
      7) Packing: Asbestos free.
      8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

C. Brass Ball Valves
1. One-Piece, Reduced-Port, Brass Ball Valves with Brass Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) CWP Rating: 400 psig (2760 kPa).
      3) Body Design: One piece.
      4) Body Material: Forged brass.
      5) Ends: Threaded.
      6) Seats: PTFE or TFE.
      7) Stem: Brass.
      8) Ball: Chrome-plated brass.
      9) Port: Reduced.
2. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Brass.
      9) Ball: Chrome-plated brass.
      10) Port: Full.
3. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
   a. Description:

1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Forged brass.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Stainless steel.
9) Ball: Stainless steel, vented.
10) Port: Full.

4. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Brass.
      9) Ball: Chrome-plated brass.
      10) Port: Regular.
5. Two-Piece, Regular-Port, Brass Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Brass or bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.
      9) Ball: Stainless steel, vented.
      10) Port: Regular.
6. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Brass.
      9) Ball: Chrome-plated brass.
      10) Port: Full.
7. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Forged brass.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.

8) Stem: Stainless steel.
9) Ball: Stainless steel, vented.
10) Port: Full.

D. Bronze Ball Valves
1. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:
a. Description:
1) Standard: MSS SP-110.
2) CWP Rating: 400 psig (2760 kPa).
3) Body Design: One piece.
4) Body Material: Bronze.
5) Ends: Threaded.
6) Seats: PTFE or TFE.
7) Stem: Bronze.
8) Ball: Chrome-plated brass.
9) Port: Reduced.
2. One-Piece, Reduced-Port, Bronze Ball Valves with Stainless-Steel Trim:
a. Description:
1) Standard: MSS SP-110.
2) CWP Rating: 600 psig (4140 kPa).
3) Body Design: One piece.
4) Body Material: Bronze.
5) Ends: Threaded.
6) Seats: PTFE or TFE.
7) Stem: Stainless steel.
8) Ball: Stainless steel, vented.
9) Port: Reduced.
3. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Bronze.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Bronze.
9) Ball: Chrome-plated brass.
10) Port: Full.
4. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).
4) Body Design: Two piece.
5) Body Material: Bronze.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Stainless steel.
9) Ball: Stainless steel, vented.
10) Port: Full.
5. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:
a. Description:
1) Standard: MSS SP-110.
2) SWP Rating: 150 psig (1035 kPa).
3) CWP Rating: 600 psig (4140 kPa).

4) Body Design: Two piece.
5) Body Material: Bronze.
6) Ends: Threaded.
7) Seats: PTFE or TFE.
8) Stem: Bronze.
9) Ball: Chrome-plated brass.
10) Port: Regular.

6. Two-Piece, Regular-Port, Bronze Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Two piece.
      5) Body Material: Bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.
      9) Ball: Stainless steel, vented.
      10) Port: Regular.
7. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Bronze.
      9) Ball: Chrome-plated brass.
      10) Port: Full.
8. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:
   a. Description:
      1) Standard: MSS SP-110.
      2) SWP Rating: 150 psig (1035 kPa).
      3) CWP Rating: 600 psig (4140 kPa).
      4) Body Design: Three piece.
      5) Body Material: Bronze.
      6) Ends: Threaded.
      7) Seats: PTFE or TFE.
      8) Stem: Stainless steel.
      9) Ball: Stainless steel, vented.
      10) Port: Full.

E. Iron Ball Valves
1. Class 125, Iron Ball Valves:
   a. Description:
      1) Standard: MSS SP-72.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Split body.
      4) Body Material: ASTM A 126, gray iron.
      5) Ends: Flanged.
      6) Seats: PTFE or TFE.
      7) Stem: Stainless steel.
      8) Ball: Stainless steel.

9) Port: Full.

F. Iron, Single-Flange Butterfly Valves
1. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
a. Description:
1) Standard: MSS SP-67, Type I.
2) CWP Rating: 150 psig (1035 kPa).
3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: EPDM.
6) Stem: One- or two-piece stainless steel.
7) Disc: Aluminum bronze.
2. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:
a. Description:
1) Standard: MSS SP-67, Type I.
2) CWP Rating: 150 psig (1035 kPa).
3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: NBR.
6) Stem: One- or two-piece stainless steel.
7) Disc: Aluminum bronze.
3. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:
a. Description:
1) Standard: MSS SP-67, Type I.
2) CWP Rating: 150 psig (1035 kPa).
3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: EPDM.
6) Stem: One- or two-piece stainless steel.
7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
4. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
a. Description:
1) Standard: MSS SP-67, Type I.
2) CWP Rating: 150 psig (1035 kPa).
3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: NBR.
6) Stem: One- or two-piece stainless steel.
7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
5. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
a. Description:
1) Standard: MSS SP-67, Type I.
2) CWP Rating: 150 psig (1035 kPa).
3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: EPDM.
6) Stem: One- or two-piece stainless steel.
7) Disc: Stainless steel.
6. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
a. Description:
1) Standard: MSS SP-67, Type I.

2) CWP Rating: 150 psig (1035 kPa).
3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
5) Seat: NBR.
6) Stem: One- or two-piece stainless steel.
7) Disc: Stainless steel.

7. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: EPDM.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Aluminum bronze.
8. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: NBR.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Aluminum bronze.
9. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: EPDM.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
10. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: NBR.
      6) Stem: One- or two-piece stainless steel.
      7) Disc: Nickel-plated or -coated, **as directed**, ductile iron.
11. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
   a. Description:
      1) Standard: MSS SP-67, Type I.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      5) Seat: EPDM.

6) Stem: One- or two-piece stainless steel.
7) Disc: Stainless steel.

12. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
    a. Description:
        1) Standard: MSS SP-67, Type I.
        2) CWP Rating: 200 psig (1380 kPa).
        3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
        4) Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
        5) Seat: NBR.
        6) Stem: One- or two-piece stainless steel.
        7) Disc: Stainless steel.

G. Iron, Grooved-End Butterfly Valves
1. 175 CWP, Iron, Grooved-End Butterfly Valves:
    a. Description:
        1) Standard: MSS SP-67, Type I.
        2) CWP Rating: 175 psig (1200 kPa).
        3) Body Material: Coated, ductile iron.
        4) Stem: Two-piece stainless steel.
        5) Disc: Coated, ductile iron.
        6) Seal: EPDM.
2. 300 CWP, Iron, Grooved-End Butterfly Valves:
    a. Description:
        1) Standard: MSS SP-67, Type I.
        2) NPS 8 (DN 50) and Smaller CWP Rating: 300 psig (2070 kPa).
        3) NPS 10 (DN 250) and Larger CWP Rating: 200 psig (1380 kPa).
        4) Body Material: Coated, ductile iron.
        5) Stem: Two-piece stainless steel.
        6) Disc: Coated, ductile iron.
        7) Seal: EPDM.

H. High-Performance Butterfly Valves
1. Class 150, Single-Flange, High-Performance Butterfly Valves:
    a. Description:
        1) Standard: MSS SP-68.
        2) CWP Rating: 285 psig (1965 kPa) at 100 deg F (38 deg C).
        3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
        4) Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
        5) Seat: Reinforced PTFE or metal.
        6) Stem: Stainless steel; offset from seat plane.
        7) Disc: Carbon steel.
        8) Service: Bidirectional.
2. Class 300, Single-Flange, High-Performance Butterfly Valves:
    a. Description:
        1) Standard: MSS SP-68.
        2) CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).
        3) Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
        4) Body Material: Carbon steel, cast iron, or ductile iron.
        5) Seat: Reinforced PTFE or metal.
        6) Stem: Stainless steel; offset from seat plane.
        7) Disc: Carbon steel.
        8) Service: Bidirectional.

I. Bronze Lift Check Valves
   1. Class 125, Lift Check Valves with Bronze Disc:
      a. Description:
         1) Standard: MSS SP-80, Type 1.
         2) CWP Rating: 200 psig (1380 kPa).
         3) Body Design: Vertical flow.
         4) Body Material: ASTM B 61 or ASTM B 62, bronze.
         5) Ends: Threaded.
         6) Disc: Bronze.
   2. Class 125, Lift Check Valves with Nonmetallic Disc:
      a. Description:
         1) Standard: MSS SP-80, Type 2.
         2) CWP Rating: 200 psig (1380 kPa).
         3) Body Design: Vertical flow.
         4) Body Material: ASTM B 61 or ASTM B 62, bronze.
         5) Ends: Threaded.
         6) Disc: NBR, PTFE, or TFE.

J. Bronze Swing Check Valves
   1. Class 125, Bronze Swing Check Valves with Bronze Disc:
      a. Description:
         1) Standard: MSS SP-80, Type 3.
         2) CWP Rating: 200 psig (1380 kPa).
         3) Body Design: Horizontal flow.
         4) Body Material: ASTM B 62, bronze.
         5) Ends: Threaded.
         6) Disc: Bronze.
   2. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
      a. Description:
         1) Standard: MSS SP-80, Type 4.
         2) CWP Rating: 200 psig (1380 kPa).
         3) Body Design: Horizontal flow.
         4) Body Material: ASTM B 62, bronze.
         5) Ends: Threaded.
         6) Disc: PTFE or TFE.
   3. Class 150, Bronze Swing Check Valves with Bronze Disc:
      a. Description:
         1) Standard: MSS SP-80, Type 3.
         2) CWP Rating: 300 psig (2070 kPa).
         3) Body Design: Horizontal flow.
         4) Body Material: ASTM B 62, bronze.
         5) Ends: Threaded.
         6) Disc: Bronze.
   4. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:
      a. Description:
         1) Standard: MSS SP-80, Type 4.
         2) CWP Rating: 300 psig (2070 kPa).
         3) Body Design: Horizontal flow.
         4) Body Material: ASTM B 62, bronze.
         5) Ends: Threaded.
         6) Disc: PTFE or TFE.

K. Iron Swing Check Valves
   1. Class 125, Iron Swing Check Valves with Metal Seats:
      a. Description:

1) Standard: MSS SP-71, Type I.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Design: Clear or full waterway.
5) Body Material: ASTM A 126, gray iron with bolted bonnet.
6) Ends: Flanged.
7) Trim: Bronze.
8) Gasket: Asbestos free.

2. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Design: Clear or full waterway.
      5) Body Material: ASTM A 126, gray iron with bolted bonnet.
      6) Ends: Flanged.
      7) Trim: Composition.
      8) Seat Ring: Bronze.
      9) Disc Holder: Bronze.
      10) Disc: PTFE or TFE.
      11) Gasket: Asbestos free.
3. Class 250, Iron Swing Check Valves with Metal Seats:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Design: Clear or full waterway.
      5) Body Material: ASTM A 126, gray iron with bolted bonnet.
      6) Ends: Flanged.
      7) Trim: Bronze.
      8) Gasket: Asbestos free.

L. Iron Swing Check Valves With Closure Control
1. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Design: Clear or full waterway.
      5) Body Material: ASTM A 126, gray iron with bolted bonnet.
      6) Ends: Flanged.
      7) Trim: Bronze.
      8) Gasket: Asbestos free.
      9) Closure Control: Factory-installed, exterior lever and spring.
2. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:
   a. Description:
      1) Standard: MSS SP-71, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Design: Clear or full waterway.
      5) Body Material: ASTM A 126, gray iron with bolted bonnet.
      6) Ends: Flanged.
      7) Trim: Bronze.
      8) Gasket: Asbestos free.
      9) Closure Control: Factory-installed, exterior lever and weight.

M. Iron, Grooved-End Swing Check Valves
1. 300 CWP, Iron, Grooved-End Swing Check Valves:
a. Description:
1) CWP Rating: 300 psig (2070 kPa).
2) Body Material: ASTM A 536, ductile iron.
3) Seal: EPDM.
4) Disc: Spring operated, ductile iron or stainless steel.

N. Iron, Center-Guided Check Valves
1. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
a. Description:
1) Standard: MSS SP-125.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Material: ASTM A 126, gray iron.
5) Style: Compact wafer.
6) Seat: Bronze.
2. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:
a. Description:
1) Standard: MSS SP-125.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Material: ASTM A 126, gray iron.
5) Style: Globe, spring loaded.
6) Ends: Flanged.
7) Seat: Bronze.
3. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
a. Description:
1) Standard: MSS SP-125.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
5) Style: Compact wafer.
6) Seat: Bronze.
4. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
a. Description:
1) Standard: MSS SP-125.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
5) Style: Globe, spring loaded.
6) Ends: Flanged.
7) Seat: Bronze.
5. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
a. Description:
1) Standard: MSS SP-125.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
4) Body Material: ASTM A 126, gray iron.
5) Style: Compact wafer, spring loaded.
6) Seat: Bronze.
6. Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:
a. Description:
1) Standard: MSS SP-125.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).

3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
4) Body Material: ASTM A 126, gray iron.
5) Style: Globe, spring loaded.
6) Ends: Flanged.
7) Seat: Bronze.

7. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Style: Compact wafer, spring loaded.
      6) Seat: Bronze.
8. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Style: Globe, spring loaded.
      6) Ends: Flanged.
      7) Seat: Bronze.
9. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Material: ASTM A 126, gray iron.
      5) Style: Compact wafer.
      6) Seat: EPDM **OR** BR, **as directed**.
10. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Material: ASTM A 126, gray iron.
      5) Style: Globe, spring loaded.
      6) Ends: Flanged.
      7) Seat: EPDM **OR** NBR, **as directed**.
11. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Style: Compact wafer.
      6) Seat: EPDM **OR** NBR, **as directed**.
12. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
   a. Description:
      1) Standard: MSS SP-125.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
      4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      5) Style: Globe, spring loaded.
      6) Ends: Flanged.
      7) Seat: EPDM **OR** NBR, **as directed**.

13. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
        4) Body Material: ASTM A 126, gray iron.
        5) Style: Compact wafer, spring loaded.
        6) Seat: EPDM **OR** NBR, **as directed**.
14. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
        4) Body Material: ASTM A 126, gray iron.
        5) Style: Globe, spring loaded.
        6) Ends: Flanged.
        7) Seat: EPDM **OR** NBR, **as directed**.
15. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
        4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        5) Style: Compact wafer, spring loaded.
        6) Seat: EPDM **OR** NBR, **as directed**.
16. Class 300, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
    a. Description:
        1) Standard: MSS SP-125.
        2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
        4) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        5) Style: Globe, spring loaded.
        6) Ends: Flanged.
        7) Seat: EPDM **OR** NBR, **as directed**.

O. Iron, Plate-Type Check Valves
1. Class 125, Iron, Dual-Plate Check Valves with Metal Seat:
    a. Description:
        1) Standard: API 594.
        2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
        4) Body Design: Wafer, spring-loaded plates.
        5) Body Material: ASTM A 126, gray iron.
        6) Seat: Bronze.
2. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:
    a. Description:
        1) Standard: API 594.
        2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
        3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
        4) Body Design: Wafer, spring-loaded plates.
        5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
        6) Seat: Bronze.
3. Class 250, Iron, Dual-Plate Check Valves with Metal Seat:
    a. Description:
        1) Standard: API 594.

2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
4) Body Design: Wafer, spring-loaded plates.
5) Body Material: ASTM A 126, gray iron.
6) Seat: Bronze.

4. Class 300, Iron, Dual-Plate Check Valves with Metal Seat:
   a. Description:
      1) Standard: API 594.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
      4) Body Design: Wafer, spring-loaded plates.
      5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      6) Seat: Bronze.
5. Class 125, Iron, Single-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Design: Wafer, spring-loaded plate.
      5) Body Material: ASTM A 126, gray iron.
      6) Seat: EPDM **OR** NBR, **as directed**.
6. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Design: Wafer, spring-loaded plates.
      5) Body Material: ASTM A 126, gray iron.
      6) Seat: EPDM **OR** NBR, **as directed**.
7. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
      4) Body Design: Wafer, spring-loaded plates.
      5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
      6) Seat: EPDM **OR** NBR, **as directed**.
8. Class 250, Iron, Wafer, Single-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Design: Wafer, spring-loaded plate.
      5) Body Material: ASTM A 126, gray iron.
      6) Seat: EPDM **OR** NBR, **as directed**.
9. Class 250, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Design: Wafer, spring-loaded plates.
      5) Body Material: ASTM A 126, gray iron.
      6) Seat: EPDM **OR** NBR, **as directed**.
10. Class 300, Iron, Dual-Plate Check Valves with Resilient Seat:
   a. Description:
      1) Standard: API 594.

2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 400 psig (2760 kPa).
4) Body Design: Wafer, spring-loaded plates.
5) Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
6) Seat: EPDM **OR** NBR, **as directed**.

P. Bronze Gate Valves
1. Class 125, NRS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
4) Ends: Threaded or solder joint, **as directed**.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, RS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
4) Ends: Threaded or solder joint, **as directed**.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, NRS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 1.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
4. Class 150, RS Bronze Gate Valves:
a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: Solid wedge; bronze.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

Q. Iron Gate Valves
1. Class 125, NRS, Iron Gate Valves:
a. Description:
1) Standard: MSS SP-70, Type I.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Material: ASTM A 126, gray iron with bolted bonnet.

5) Ends: Flanged.
6) Trim: Bronze.
7) Disc: Solid wedge.
8) Packing and Gasket: Asbestos free.

2. Class 125, OS&Y, Iron Gate Valves:
   a. Description:
      1) Standard: MSS SP-70, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Disc: Solid wedge.
      8) Packing and Gasket: Asbestos free.
3. Class 250, NRS, Iron Gate Valves:
   a. Description:
      1) Standard: MSS SP-70, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Disc: Solid wedge.
      8) Packing and Gasket: Asbestos free.
4. Class 250, OS&Y, Iron Gate Valves:
   a. Description:
      1) Standard: MSS SP-70, Type I.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Material: ASTM A 126, gray iron with bolted bonnet.
      5) Ends: Flanged.
      6) Trim: Bronze.
      7) Disc: Solid wedge.
      8) Packing and Gasket: Asbestos free.

R. Bronze Globe Valves
1. Class 125, Bronze Globe Valves with Bronze Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 1.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      4) Ends: Threaded or solder joint, **as directed**.
      5) Stem and Disc: Bronze.
      6) Packing: Asbestos free.
      7) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
2. Class 125, Bronze Globe Valves with Nonmetallic Disc:
   a. Description:
      1) Standard: MSS SP-80, Type 2.
      2) CWP Rating: 200 psig (1380 kPa).
      3) Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
      4) Ends: Threaded or solder joint, **as directed**.
      5) Stem: Bronze.
      6) Disc: PTFE or TFE.
      7) Packing: Asbestos free.
      8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.
3. Class 150, Bronze Globe Valves with Nonmetallic Disc:

a. Description:
1) Standard: MSS SP-80, Type 2.
2) CWP Rating: 300 psig (2070 kPa).
3) Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4) Ends: Threaded.
5) Stem: Bronze.
6) Disc: PTFE or TFE.
7) Packing: Asbestos free.
8) Handwheel: Malleable iron, bronze, or aluminum, **as directed**.

S. Iron Globe Valves
1. Class 125, Iron Globe Valves:
a. Description:
1) Standard: MSS SP-85, Type I.
2) CWP Rating: 200 psig (1380 kPa).
3) Body Material: ASTM A 126, gray iron with bolted bonnet.
4) Ends: Flanged.
5) Trim: Bronze.
6) Packing and Gasket: Asbestos free.
2. Class 250, Iron Globe Valves:
a. Description:
1) Standard: MSS SP-85, Type I.
2) CWP Rating: 500 psig (3450 kPa).
3) Body Material: ASTM A 126, gray iron with bolted bonnet.
4) Ends: Flanged.
5) Trim: Bronze.
6) Packing and Gasket: Asbestos free.

T. Lubricated Plug Valves
1. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
a. Description:
1) Standard: MSS SP-78, Type II.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
5) Pattern: Regular or short **OR** Venturi, **as directed**.
6) Plug: Cast iron or bronze with sealant groove.
2. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
a. Description:
1) Standard: MSS SP-78, Type II.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
5) Pattern: Regular or short **OR** Venturi, **as directed**.
6) Plug: Cast iron or bronze with sealant groove.
3. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
a. Description:
1) Standard: MSS SP-78, Type IV.
2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
5) Pattern: Regular or short **OR** Venturi, **as directed**.

6) Plug: Cast iron or bronze with sealant groove.

4. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
   a. Description:
      1) Standard: MSS SP-78, Type IV.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
      4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      5) Pattern: Regular or short **OR** Venturi, **as directed**.
      6) Plug: Cast iron or bronze with sealant groove.
5. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
   a. Description:
      1) Standard: MSS SP-78, Type II.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      5) Pattern: Regular or short **OR** Venturi, **as directed**.
      6) Plug: Cast iron or bronze with sealant groove.
6. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
   a. Description:
      1) Standard: MSS SP-78, Type II.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      5) Pattern: Regular or short **OR** Venturi, **as directed**.
      6) Plug: Cast iron or bronze with sealant groove.
7. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
   a. Description:
      1) Standard: MSS SP-78, Type IV.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      5) Pattern: Regular or short **OR** Venturi, **as directed**.
      6) Plug: Cast iron or bronze with sealant groove.
8. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:
   a. Description:
      1) Standard: MSS SP-78, Type IV.
      2) NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 400 psig (2760 kPa).
      3) NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
      4) Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
      5) Pattern: Regular or short **OR** Venturi, **as directed**.
      6) Plug: Cast iron or bronze with sealant groove.

U. Eccentric Plug Valves
1. 175 CWP, Eccentric Plug Valves with Resilient Seating.
   a. Description:
      1) Standard: MSS SP-108.
      2) CWP Rating: 175 psig (1200 kPa) minimum.
      3) Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
      4) Bearings: Oil-impregnated bronze or stainless steel.
      5) Ends: Flanged.

6) Stem-Seal Packing: Asbestos free.
7) Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

V. Chainwheels
1. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
a. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
b. Attachment: For connection to ball **OR** butterfly **OR** plug, **as directed**, valve stems.
c. Sprocket Rim with Chain Guides: Ductile iron **OR** Cast iron **OR** Aluminum **OR** Bronze, **as directed**, of type and size required for valve. Include zinc coating, **as directed**.
d. Chain: Hot-dip, galvanized steel **OR** Brass **OR** Stainless steel, **as directed**, of size required to fit sprocket rim.

1.3 EXECUTION

A. Valve Installation
1. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
2. Locate valves for easy access and provide separate support where necessary.
3. Install valves in horizontal piping with stem at or above center of pipe.
4. Install valves in position to allow full stem movement.
5. Install chainwheels on operators for ball **OR** butterfly **OR** gate **OR** globe **OR** plug, **as directed**, valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
6. Install check valves for proper direction of flow and as follows:
a. Swing Check Valves: In horizontal position with hinge pin level.
b. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
c. Lift Check Valves: With stem upright and plumb.

B. Adjusting
1. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

C. General Requirements For Valve Applications
1. If valve applications are not indicated, use the following:
a. Shutoff Service: Ball, butterfly **OR** gate **OR** plug, **as directed**, valves.
b. Butterfly Valve Dead-End Service: Single-flange (lug) type.
c. Throttling Service except Steam: Globe **OR** angle **OR** ball **OR** butterfly, **as directed**, valves.
d. Throttling Service, Steam: Globe **OR** angle **OR** butterfly, **as directed**, valves.
e. Pump-Discharge Check Valves:
1) NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze **OR** nonmetallic, **as directed**, disc.
2) NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal **OR** resilient, **as directed**,-seat check valves.
2. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
3. Select valves, except wafer types, with the following end connections:
a. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
b. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.

c. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
d. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
e. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
f. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
g. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

D. Chilled-Water Valve Schedule
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**, bronze.
f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
c. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
d. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): 150 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
e. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 175 **OR** 300, **as directed**, CWP.
f. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
g. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
h. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
i. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
j. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
k. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
l. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
m. Iron Globe Valves: Class 125 **OR** Class 250, **as directed**.
n. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.
o. Eccentric Plug Valves: 175 CWP, resilient seating.

E. Condenser-Water Valve Schedule
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.

b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.

2. Pipe NPS 2-1/2 (DN 65) and Larger:
a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
c. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
d. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): 150 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
e. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 175 **OR** 300, **as directed**, CWP.
f. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
g. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
h. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
i. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
j. Iron, Center-Guided Check Valves, NPS 2-1/2 to NPS 24 (DN 65 to DN 600): Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, metal **OR** resilient, **as directed**, seat.
k. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
l. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
m. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
n. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.

F. Heating-Water Valve Schedule
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze and Brass Valves: May be provided with solder-joint ends instead of threaded ends.
b. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
c. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
d. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
e. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
f. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:

a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
c. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 200 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
d. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24 (DN 350 to DN 600): 150 CWP, EPDM **OR** NBR, **as directed**, seat, aluminum-bronze **OR** ductile-iron **OR** stainless-steel, **as directed**, disc.
e. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 175 **OR** 300, **as directed**, CWP.
f. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
g. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
h. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
i. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
j. Iron, Center-Guided Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**, compact-wafer **OR** globe, **as directed**, metal **OR** resilient, **as directed**, seat.
k. Iron, Plate-Type Check Valves: Class 125 **OR** Class 150 **OR** Class 250 **OR** Class 300, **as directed**; single **OR** dual, **as directed**, plate; metal **OR** resilient, **as directed**, seat.
l. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
m. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.

G. Low-Pressure Steam Valve Schedule (15 psig (104 kPa) Or Less)
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
c. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
d. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
e. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
c. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
e. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
g. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.

H. High-Pressure Steam Valve Schedule (More Than 15 psig (104 kPa))
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.

b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
c. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
d. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**, bronze.
e. Globe Valves: Class 125 **OR** 150, **as directed**, bronze, bronze **OR** nonmetallic, **as directed**, disc.

2. Pipe Sizes NPS 2-1/2 (DN 65) and Larger:
a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150, iron.
c. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
e. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125, lever and spring **OR** weight, **as directed**.
f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
g. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.

I. Steam-Condensate Valve Schedule
1. Pipe NPS 2 (DN 50) and Smaller:
a. Bronze Angle Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
b. Ball Valves: One **OR** Two **OR** Three, **as directed**, piece, full **OR** regular **OR** reduced, **as directed**, port, brass **OR** bronze, **as directed**, with brass **OR** bronze **OR** stainless-steel, **as directed**, trim.
c. Bronze Swing Check Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.
d. Bronze Gate Valves: Class 125 **OR** Class 150, **as directed**, NRS **OR** RS, **as directed**.
e. Bronze Globe Valves: Class 125 **OR** Class 150, **as directed**, bronze **OR** nonmetallic, **as directed**, disc.

2. Pipe NPS 2-1/2 (DN 65) and Larger:
a. Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
b. Iron Ball Valves, NPS 2-1/2 to NPS 10 (DN 65 to DN 250): Class 150.
c. High-Performance Butterfly Valves: Class 150 **OR** Class 300, **as directed**, single flange.
d. Iron Swing Check Valves: Class 125 **OR** Class 250, **as directed**, metal **OR** nonmetallic-to-metal, **as directed**, seats.
e. Iron Swing Check Valves with Closure Control: Class 125, lever and spring **OR** weight, **as directed**.
f. Iron Gate Valves: Class 125 **OR** Class 250, **as directed**, NRS **OR** OS&Y, **as directed**.
g. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): Class 125 **OR** Class 250, **as directed**.
h. Lubricated Plug Valves: Class 125 **OR** Class 250, **as directed**, regular gland **OR** cylindrical, **as directed**, threaded **OR** flanged, **as directed**.

END OF SECTION 15101a

Task	Specification	Specification Description
15101	02242	Piped Utilities Basic Materials And Methods
15101	02455a	Water Distribution
15102	02242	Piped Utilities Basic Materials And Methods
15102	15101	General-Duty Valves for Plumbing Piping
15102	15101a	General-Duty Valves for HVAC Piping
15103	02242	Piped Utilities Basic Materials And Methods
15103	15101	General-Duty Valves for Plumbing Piping
15103	15101a	General-Duty Valves for HVAC Piping
15104	02242	Piped Utilities Basic Materials And Methods
15104	15101	General-Duty Valves for Plumbing Piping
15104	15101a	General-Duty Valves for HVAC Piping
15104	15061f	Hydronic Piping
15104	15061j	General-Service Compressed-Air Piping
15105	02242	Piped Utilities Basic Materials And Methods
15105	15101	General-Duty Valves for Plumbing Piping
15105	15101a	General-Duty Valves for HVAC Piping
15106	02242	Piped Utilities Basic Materials And Methods
15106	15061h	Refrigerant Piping
15107	02242	Piped Utilities Basic Materials And Methods
15107	15083	Hydronic Pumps
15108	02242	Piped Utilities Basic Materials And Methods
15109	02242	Piped Utilities Basic Materials And Methods
15109	02455a	Water Distribution

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SECTION 15110 - STORM DRAINAGE PIPING SPECIALTIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for storm drainage piping specialties. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Roof drains.
b. Miscellaneous storm drainage piping specialties.
c. Cleanouts.
d. Backwater valves.
e. Trench drains.
f. Channel drainage systems.
g. Through-penetration firestop assemblies.
h. Flashing materials.

C. Submittals
1. Product Data: For each type of product indicated.

D. Quality Assurance
1. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.2 PRODUCTS

A. Metal Roof Drains
1. Cast-Iron, Large-Sump, General-Purpose Roof Drains:
a. Standard: ASME A112.6.4, for general-purpose roof drains.
b. Body Material: Cast iron.
c. Dimension of Body: Nominal 14-inch (357-mm) diameter.
d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
e. Flow-Control Weirs: Not required **OR** Required, **as directed**.
f. Outlet: Bottom **OR** Side, **as directed**.
g. Extension Collars: Not required **OR** Required, **as directed**.
h. Underdeck Clamp: Not required **OR** Required, **as directed**.
i. Expansion Joint: Not required **OR** Required, **as directed**.
j. Sump Receiver Plate: Not required **OR** Required, **as directed**.
k. Dome Material: Aluminum **OR** Cast iron **OR** PE **OR** Stainless steel, **as directed**.
l. Perforated Gravel Guard: Stainless steel **OR** Not required, **as directed**.
m. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
n. Water Dam: Not required **OR** 2 inches (51 mm) high, **as directed**.
2. Cast-Iron, Medium-Sump, General-Purpose Roof Drains:
a. Standard: ASME A112.6.4, for general-purpose roof drains.
b. Body Material: Cast iron.
c. Dimension of Body: 8- to 12-inch (203- to 305-mm) diameter.
d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
e. Flow-Control Weirs: Not required **OR** Required, **as directed**.
f. Outlet: Bottom **OR** Side, **as directed**.
g. Extension Collars: Not required **OR** Required, **as directed**.

h. Underdeck Clamp: Not required **OR** Required, **as directed**.
i. Expansion Joint: Not required **OR** Required, **as directed**.
j. Sump Receiver Plate: Not required **OR** Required, **as directed**.
k. Dome Material: Aluminum **OR** Cast iron **OR** Copper **OR** PE **OR** Stainless steel, **as directed**.
l. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
m. Perforated Gravel Guard: Stainless steel **OR** Not required, **as directed**.
n. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
o. Water Dam: Not required **OR** 2 inches (51 mm) high, **as directed**.

3. Copper, Medium-Sump, General-Purpose Roof Drains:
   a. Standard: ASME A112.6.4, for general-purpose roof drains.
   b. Body Material: Copper.
   c. Dimension of Body: 8- to 12-inch (203- to 305-mm) diameter.
   d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
   e. Flow-Control Weirs: Not required **OR** Required, **as directed**.
   f. Outlet: Bottom **OR** Side, **as directed**.
   g. Extension Collars: Not required **OR** Required, **as directed**.
   h. Underdeck Clamp: Not required **OR** Required, **as directed**.
   i. Expansion Joint: Not required **OR** Required, **as directed**.
   j. Sump Receiver Plate: Not required **OR** Required, **as directed**.
   k. Dome Material: Aluminum **OR** Cast iron **OR** Copper **OR** PE **OR** Stainless steel, **as directed**.
   l. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
   m. Perforated Gravel Guard: Stainless steel **OR** Not required, **as directed**.
   n. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
   o. Water Dam: Not required **OR** 2 inches (51 mm) high, **as directed**.
4. Cast-Iron, Small-Sump, General-Purpose Roof Drains:
   a. Standard: ASME A112.6.4, for general-purpose roof drains.
   b. Body Material: Cast iron.
   c. Dimension of Body: Nominal 8-inch (203-mm) diameter.
   d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
   e. Outlet: Bottom **OR** Side, **as directed**.
   f. Extension Collars: Not required **OR** Required, **as directed**.
   g. Underdeck Clamp: Not required **OR** Required, **as directed**.
   h. Expansion Joint: Not required **OR** Required, **as directed**.
   i. Sump Receiver Plate: Not required **OR** Required, **as directed**.
   j. Dome Material: Cast iron.
   k. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
   l. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
5. Copper, Small-Sump, General-Purpose Roof Drains:
   a. Standard: ASME A112.6.4, for general-purpose roof drains.
   b. Body Material: Copper.
   c. Dimension of Body: Nominal 8-inch (203-mm) diameter.
   d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
   e. Outlet: Bottom **OR** Side, **as directed**.
   f. Extension Collars: Not required **OR** Required, **as directed**.
   g. Underdeck Clamp: Not required **OR** Required, **as directed**.
   h. Expansion Joint: Not required **OR** Required, **as directed**.
   i. Sump Receiver Plate: Not required **OR** Required, **as directed**.
   j. Dome Material: Cast iron.
   k. Wire Mesh: Stainless steel or brass over dome **OR** Not required, **as directed**.
   l. Vandal-Proof Dome: Not required **OR** Required, **as directed**.
6. Metal, Cornice and Gutter Roof Drains:
   a. Standard: ASME A112.6.4, for cornice and gutter roof drains.
   b. Body Material: Metal.

c. Dimension of Body: Nominal 6-inch (152-mm) diameter.
d. Outlet: Bottom **OR** Side **OR** 45-degree angle, **as directed**.
e. Dome Material: Bronze.
f. Vandal-Proof Dome: Not required **OR** Required, **as directed**.

7. Metal, Parapet Roof Drains:
   a. Standard: ASME A112.6.4, for parapet roof drains.
   b. Body Material: Cast iron.
   c. Outlet: Back **OR** Angle, **as directed**.
   d. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directd**.
   e. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
8. Metal, Large-Sump, Promenade Roof Drains:
   a. Standard: ASME A112.6.4, for promenade roof drains.
   b. Body Material: Cast iron.
   c. Dimension of Body: Nominal 14-inch (357-mm) diameter.
   d. Dimension of Frame and Grate: Nominal 14 inches (357 mm) square.
   e. Outlet: Bottom.
   f. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
   g. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
   h. Extension Collars: Not required **OR** Required, **as directed**.
   i. Underdeck Clamp: Not required **OR** Required, **as directed**.
   j. Expansion Joint: Not required **OR** Required, **as directed**.
   k. Sump Receiver Plate: Not required **OR** Required, **as directed**.
9. Metal, Medium-Sump, Promenade Roof Drains:
   a. Standard: ASME A112.6.4, for promenade roof drains.
   b. Body Material: Cast iron.
   c. Dimension of Body: 11- to 12-inch (280- to 305-mm) diameter.
   d. Dimension of Frame and Grate: Nominal 12 inches (305 mm) square.
   e. Outlet: Bottom.
   f. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
   g. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
   h. Extension Collars: Not required **OR** Required, **as directed**.
   i. Underdeck Clamp: Not required **OR** Required, **as directed**.
   j. Expansion Joint: Not required **OR** Required, **as directed**.
   k. Sump Receiver Plate: Not required **OR** Required, **as directed**.
10. Metal, Small-Sump, Promenade Roof Drains:
    a. Standard: ASME A112.6.4, for promenade roof drains.
    b. Body Material: Cast iron.
    c. Dimension of Body: Nominal 8-inch (203-mm) diameter.
    d. Dimension of Frame and Grate: Nominal 8 inches (203 mm) square.
    e. Outlet: Bottom.
    f. Grate Material: Bronze **OR** Cast iron **OR** Nickel-bronze alloy, **as directed**.
    g. Vandal-Proof Grate: Not required **OR** Required, **as directed**.
    h. Extension Collars: Not required **OR** Required, **as directed**.
    i. Underdeck Clamp: Not required **OR** Required, **as directed**.
    j. Expansion Joint: Not required **OR** Required, **as directed**.
    k. Sump Receiver Plate: Not required **OR** Required, **as directed**.
11. Metal, Medium-Sump, Deck Roof Drains:
    a. Standard: ASME A112.6.4, for deck roof drains; ASME A112.6.3, for floor drains.
    b. Body Material: Metal.
    c. Flange: Anchor **OR** Anchor with weep holes **OR** Not required, **as directed**.
    d. Clamping Device: Not required **OR** Required, **as directed**.
    e. Integral Backwater Valve: Not required **OR** Required, **as directed**.
    f. Outlet: Bottom **OR** End **OR** Side, **as directed**.
    g. Grate Material: Cast iron.
    h. Grate Finish: Painted **OR** Not required, **as directed**.

i. Overall Dimension of Frame and Grate: Nominal 14 inches (357 mm) round **OR** square, **as directed**.
j. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty, **as directed**.
k. Vandal-Proof Frame and Grate: Not required **OR** Required, **as directed**.

12. Metal, Small-Sump, Deck Roof Drains:
    a. Standard: ASME A112.6.4, for deck roof drains; ASME A112.6.3, for floor drains.
    b. Body Material: Metal.
    c. Flange: Anchor **OR** Anchor with weep holes **OR** Not required, **as directed**.
    d. Clamping Device: Not required **OR** Required, **as directed**.
    e. Integral Backwater Valve: Not required **OR** Required, **as directed**.
    f. Outlet: Bottom **OR** End **OR** Side, **as directed**.
    g. Grate Material: Cast iron.
    h. Grate Finish: Painted **OR** Not required, **as directed**.
    i. Overall Dimension of Frame and Grate: Nominal 8 inches (203 mm) round **OR** square, **as directed**.
    j. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty **OR** Light Duty **OR** Medium Duty, **as directed**.
    k. Vandal-Proof Frame and Grate: Not required **OR** Required, **as directed**.

B. Plastic Roof Drains
1. Plastic Roof Drains:
    a. Standard: ASME A112.6.4, for plastic roof drains.
    b. Body Material: ABS or PVC.
    c. Sump Diameter: <**Insert nominal dimension**>.
    d. Combination Flashing Ring and Gravel Stop: Not required **OR** Required, **as directed**.
    e. Outlet: Bottom.
    f. Extension Collars: Not required **OR** Required, **as directed**.
    g. Underdeck Clamp: Not required **OR** Required, **as directed**.
    h. Expansion Joint: Not required **OR** Required, **as directed**.
    i. Sump Receiver Plate: Not required **OR** Required, **as directed**.
    j. Dome Material: Aluminum **OR** Cast iron **OR** PE **OR** Stainless steel, **as directed**.
    k. Vandal-Proof Dome: Not required **OR** Required, **as directed**.

C. Miscellaneous Storm Drainage Piping Specialties
1. Downspout Adaptors:
    a. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
    b. Size: Inlet size to match parapet drain outlet.
2. Downspout Boots:
    a. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 (DN 100) outlet; and shop-applied bituminous coating.
    b. Size: Inlet size to match downspout and NPS 4 (DN 100) outlet.
3. Conductor Nozzles:
    a. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
    b. Size: Same as connected conductor.

D. Cleanouts
1. Floor Cleanouts:
    a. Standard: ASME A112.36.2M, for adjustable housing **OR** cast-iron soil pipe with cast-iron ferrule **OR** heavy-duty, adjustable housing **OR** threaded, adjustable housing, **as directed**, cleanouts.
    b. Size: Same as connected branch.
    c. Type: Adjustable housing **OR** Cast-iron soil pipe with cast-iron ferrule **OR** Heavy-duty, adjustable housing **OR** Threaded, adjustable housing, **as directed**.
    d. Body or Ferrule Material: Cast iron **OR** Stainless steel, **as directed**.

e. Clamping Device: Not required **OR** Required, **as directed**.
f. Outlet Connection: Inside calk **OR** Spigot **OR** Threaded, **as directed**.
g. Closure: Brass plug with straight threads and gasket **OR** Brass plug with tapered threads **OR** Cast-iron plug **OR** Plastic plug, **as directed**.
h. Adjustable Housing Material: Cast iron **OR** Plastic, **as directed**, with threads **OR** set-screws or other device, **as directed**.
i. Frame and Cover Material and Finish: Nickel-bronze, copper alloy **OR** Painted cast iron **OR** Polished bronze **OR** Rough bronze **OR** Stainless steel, **as directed**.
j. Frame and Cover Shape: Round **OR** Square, **as directed**.
k. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty **OR** Light Duty **OR** Medium Duty, **as directed**.
l. Riser: ASTM A 74, Extra-Heavy **OR** Service, **as directed**, class, cast-iron drainage pipe fitting and riser to cleanout.

2. Test Tees:
   a. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
   b. Size: Same as connected drainage piping.
   c. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
   d. Closure Plug: Countersunk or raised head, brass.
   e. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
3. Wall Cleanouts:
   a. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
   b. Size: Same as connected drainage piping.
   c. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch **OR** Hubless, cast-iron soil-pipe test tee, **as directed**, as required to match connected piping.
   d. Closure: Countersunk **OR** Countersunk or raised-head **OR** Raised-head, **as directed**, drilled-and-threaded **OR** brass **OR** cast-iron, **as directed**, plug.
   e. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
   f. Wall Access: Round, deep, chrome-plated bronze **OR** flat, chrome-plated brass or stainless-steel, **as directed**, cover plate with screw.
   g. Wall Access: Round **OR** Square, **as directed**, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.
4. Plastic Floor Cleanouts:
   a. Size: Same as connected branch.
   b. Body Material: PVC.
   c. Closure Plug: PVC.
   d. Riser: Drainage pipe fitting and riser to cleanout of same material as drainage piping.

E. Backwater Valves
1. Cast-Iron, Horizontal Backwater Valves:
   a. Standard: ASME A112.14.1, for backwater valves.
   b. Size: Same as connected piping.
   c. Body Material: Cast iron.
   d. Cover: Cast iron with bolted or threaded access check valve.
   e. End Connections: Hub and spigot or hubless.
   f. Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed **OR** open for airflow unless subject to backflow condition, **as directed**.
   g. Extension: ASTM A 74, Service class; full-size, cast-iron soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.
2. Cast-Iron, Drain-Outlet Backwater Valves:
   a. Size: Same as floor drain outlet.
   b. Body Material: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
   c. Check Valve: Removable ball float.
   d. Inlet: Threaded.

e. Outlet: Threaded or spigot.

3. Plastic, Horizontal Backwater Valves:
   a. Standard: ASME A112.14.1, for backwater valves.
   b. Size: Same as connected piping.
   c. Body Material: ABS **OR** PVC, **as directed**.
   d. Cover: Same material as body with threaded access to check valve.
   e. Check Valve: Removable swing check.
   f. End Connections: Socket type.

F. Trench Drains
1. Trench Drains:
   a. Standard: ASME A112.6.3, for trench drains.
   b. Body Material: Cast iron.
   c. Flange: Anchor **OR** Anchor with weep holes **OR** Not required, **as directed**.
   d. Clamping Device: Not required **OR** Required, **as directed**.
   e. Outlet: Bottom **OR** End **OR** Side, **as directed**.
   f. Grate Material: Ductile iron or gray iron **OR** stainless steel, **as directed**.
   g. Grate Finish: Painted **OR** Not required, **as directed**.
   h. Dimensions of Frame and Grate: <**Insert dimensions**>.
   i. Top-Loading Classification: Extra-Heavy Duty **OR** Heavy Duty **OR** Light Duty **OR** Medium Duty, **as directed**.

G. Channel Drainage Systems
1. Narrow, Sloped-Invert, Polymer-Concrete, Channel Drainage Systems:
   a. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
      1) Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps. Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.
         a) Dimensions: 4-inch (102-mm) inside width. Include number of units required to form total lengths indicated.
         b) Frame: Galvanized steel or gray iron for grates **OR** Not required, **as directed**.
      2) Grates: Manufacturer's designation "heavy duty" **OR** “medium duty", **as directed**, with slots or perforations, and of width and thickness that fit recesses in channel sections.
         a) Material: Ductile iron **OR** Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
         b) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections **OR** Not required, **as directed**.
      3) Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
      4) Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
      5) Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
2. Narrow, Level-Invert, Polymer-Concrete, Channel Drainage Systems:
   a. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.
      1) Channel Sections: Narrow, interlocking-joint, precast, polymer-concrete modular units with end caps. Include rounded bottom, with level invert and with NPS 4 (DN 100) outlets in number and locations indicated.
         a) Dimensions: 5-inch (127-mm) inside width and 9-3/4-inch (248-mm) depth. Include number of units required to form total lengths indicated.

b) Frame: Galvanized steel or gray iron for grates **OR** Not required, **as directed**.

2) Grates: Manufacturer's designation "heavy duty" **OR** "medium duty", **as directed,** with slots or perforations, and of width and thickness that fit recesses in channel sections.

a) Material: Ductile iron **OR** Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.

b) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections **OR** Not required, **as directed**.

3) Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.

4) Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

5) Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

3. Wide, Level-Invert, Polymer-Concrete, Channel Drainage Systems:

a. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.

1) Channel Sections: Wide, interlocking-joint, precast, polymer-concrete modular units with end caps. Include flat or rounded bottom, with level invert and with outlets in number, sizes, and locations indicated.

a) Dimensions: 8-inch (203-mm) inside width and 13-3/4-inch (350-mm) depth. Include number of units required to form total lengths indicated.

b) Frame: Galvanized steel or gray iron for grates **OR** Not required, **as directed**.

2) Grates: Manufacturer's designation "heavy duty" **OR** "medium duty", **as directed**, with slots or perforations, and of width and thickness that fit recesses in channel sections.

a) Material: Ductile iron **OR** Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.

b) Locking Mechanism: Manufacturer's standard device for securing grates to channel sections **OR** Not required, **as directed**.

3) Covers: Solid ductile or gray iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.

4) Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

5) Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

H. Through-Penetration Firestop Assemblies

1. Through-Penetration Firestop Assemblies:

a. Standard: ASTM E 814, for through-penetration firestop assemblies.

b. Certification and Listing: Intertek Testing Service NA for through-penetration firestop assemblies.

c. Size: Same as connected pipe.

d. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

e. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.

f. Special Coating: Corrosion resistant on interior of fittings.

I. Flashing Materials

1. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).

2. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.
3. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.
4. Fasteners: Metal compatible with material and substrate being fastened.
5. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
6. Solder: ASTM B 32, lead-free alloy.

1.3 EXECUTION

A. Installation
1. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 7 Sections.
   a. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
   b. Install expansion joints, if indicated, in roof drain outlets.
   c. Position roof drains for easy access and maintenance.
2. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
3. Install downspout boots at grade with top 6 inches (152 mm) **OR** 12 inches (305 mm) **OR** 18 inches (457 mm), **as directed**, above grade. Secure to building wall.
4. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
5. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
   a. Use cleanouts the same size as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
   b. Locate cleanouts at each change in direction of piping greater than 45 degrees.
   c. Locate cleanouts at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
   d. Locate cleanouts at base of each vertical soil and waste stack.
6. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
7. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
8. Install horizontal backwater valves in floor with cover flush with floor.
9. Install drain-outlet backwater valves in outlet of drains.
10. Install test tees in vertical conductors and near floor.
11. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
12. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
13. Assemble channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
14. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.
15. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

B. Connections
1. Comply with requirements for piping specified in Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

C. Flashing Installation

1. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
   a. Lead Sheets: Burn joints of 6.0-lb/sq. ft. (30-kg/sq. m) lead sheets, 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of 4.0-lb/sq. ft. (20-kg/sq. m) lead sheets, 0.0625-inch (1.6-mm) thickness or thinner.
   b. Copper Sheets: Solder joints of copper sheets.
2. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
   a. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches (250 mm) and with skirt or flange extending at least 8 inches (200 mm) around pipe.
   b. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
   c. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
3. Set flashing on floors and roofs in solid coating of bituminous cement.
4. Secure flashing into sleeve and specialty clamping ring or device.
5. Fabricate and install flashing and pans, sumps, and other drainage shapes.

D. Protection
1. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
2. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 15110

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Task	Specification	Specification Description
15110	02242	Piped Utilities Basic Materials And Methods
15110	02455a	Water Distribution
15111	02242	Piped Utilities Basic Materials And Methods
15111	02455a	Water Distribution
15112	01352	No Specification Required
15112	02242	Piped Utilities Basic Materials And Methods
15112	02455a	Water Distribution
15112	02455b	Sanitary Sewerage
15112	02452	Storm Drainage
15113	02242	Piped Utilities Basic Materials And Methods
15113	15061h	Refrigerant Piping
15115	01352	No Specification Required
15115	02242	Piped Utilities Basic Materials And Methods
15116	01352	No Specification Required
15117	02242	Piped Utilities Basic Materials And Methods
15117	02455b	Sanitary Sewerage
15117	02452	Storm Drainage
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15121	02242	Piped Utilities Basic Materials And Methods
15121	02455a	Water Distribution
15121	15061f	Hydronic Piping
15121	15061g	Steam And Condensate Piping
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15121	15061j	General-Service Compressed-Air Piping
15122	02242	Piped Utilities Basic Materials And Methods
15122	02455a	Water Distribution
15122	15061g	Steam And Condensate Piping
15122	15061h	Refrigerant Piping
15122	15061j	General-Service Compressed-Air Piping
15123	02242	Piped Utilities Basic Materials And Methods
15123	15061g	Steam And Condensate Piping
15123	15061h	Refrigerant Piping
15124	02242	Piped Utilities Basic Materials And Methods
15125	02242	Piped Utilities Basic Materials And Methods
15125	02456b	Steam Distribution
15130	02242	Piped Utilities Basic Materials And Methods
15140	02242	Piped Utilities Basic Materials And Methods
15141	02242	Piped Utilities Basic Materials And Methods
15141	02456	Water Supply Wells
15141	15083	Hydronic Pumps
15142	02242	Piped Utilities Basic Materials And Methods
15143	02242	Piped Utilities Basic Materials And Methods
15143	02456	Water Supply Wells
15143	13920b	Electric-Drive, Vertical-Turbine Fire Pumps
15143	13920c	Diesel-Drive, Vertical-Turbine Fire Pumps
15144	02242	Piped Utilities Basic Materials And Methods
15144	15083	Hydronic Pumps

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SECTION 15145 - SUMP PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for sump pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Submersible sump pumps.
b. Wet-pit-volute sump pumps.
c. Sump-pump basins and basin covers.
d. Packaged drainage-pump units.

C. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

E. Delivery, Storage, And Handling
1. Retain shipping flange protective covers and protective coatings during storage.
2. Protect bearings and couplings against damage.
3. Comply with pump manufacturer's written rigging instructions for handling.

1.2 PRODUCTS

A. Submersible Sump Pumps
1. Submersible, Fixed-Position, Single-Seal Sump Pumps:
a. Description: Factory-assembled and -tested sump-pump unit.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, semiopen, **as directed**, design for clear wastewater handling, and keyed and secured to shaft.
e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
f. Seal: Mechanical.

g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   1) Motor Housing Fluid: Air **OR** Oil, **as directed**.

h. Controls (rod-and-float type):
   1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
   2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
   3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
   4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
   5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

i. Controls (float- and pressure-switch types):
   1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
   2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
   3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
   4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Control-Interface Features:
   1) Remote Alarm Contacts: For remote alarm interface.
   2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
      a) On-off status of pump.
      b) Alarm status.

2. Submersible, Fixed-Position, Double-Seal Sump Pumps:

a. Description: Factory-assembled and -tested sump-pump unit.

b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.

c. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.

d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, semiopen, **as directed**, design for clear wastewater handling, and keyed and secured to shaft.

e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.

f. Seals: Mechanical.

g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   1) Motor Housing Fluid: Air **OR** Oil, **as directed**.

i. Controls (rod-and-float type):
   1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
   2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
   3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
   4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).

5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Controls (float- and pressure-switch types):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

k. Control-Interface Features:
1) Remote Alarm Contacts: For remote alarm interface.
2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
a) On-off status of pump.
b) Alarm status.

B. Wet-Pit-Volute Sump Pumps
1. Description: Factory-assembled and -tested sump-pump unit.
2. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with strainer inlet and threaded connection for NPS 2 (DN 50) and smaller and flanged connection for NPS 2-1/2 (DN 65) and larger discharge piping.
4. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, semiopen, **as directed**, design for clear wastewater handling, and keyed and secured to shaft.
5. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch (1200-mm) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.
6. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
7. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
8. Support Plate: Cast iron or coated steel and strong enough to support pumps, motors, and controls. Refer to Part 1.2 "Sump-Pump Basins and Basin Covers" Article for requirements.
9. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
10. Motor: Single-speed; grease-lubricated ball bearings and mounting on vertical, cast-iron pedestal.
11. Controls (rod-and-float type):
a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
12. Controls (float- and pressure-switch types):
a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
b. Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.

c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

13. Control-Interface Features:
a. Remote Alarm Contacts: For remote alarm interface.
b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
1) On-off status of pump.
2) Alarm status.

C. Sump-Pump Basins And Basin Covers
1. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
a. Material: Cast iron **OR** Fiberglass **OR** Polyethylene, **as directed**.
b. Reinforcement: Mounting plates for pumps, fittings, and accessories.
c. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
2. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
a. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

D. Packaged Drainage-Pump Units
1. Packaged Pedestal Drainage-Pump Units:
a. Description: Factory-assembled and -tested, automatic-operation, freestanding, sump-pump unit.
b. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Corrosion-resistant material, with strainer inlet, design that permits flow into impeller, and vertical discharge for piping connection.
d. Impeller: Aluminum, brass, or plastic.
e. Motor: With built-in overload protection and mounted vertically on sump pump column.
f. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm), with grounding plug and cable-sealing assembly for connection at pump.
g. Control: Float switch.
2. Packaged Submersible Drainage-Pump Units:
a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, sump-pump unit.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
c. Casing: Metal.
d. Impeller: Brass.
e. Pump Seal: Mechanical.
f. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection.
g. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm), with grounding plug and cable-sealing assembly for connection at pump.
h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
i. Control: Motor-mounted float switch.

j. Basin: Plastic.

E. Motors
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Plumbing Equipment".
a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.
2. Motors for submersible pumps shall be hermetically sealed.

1.3 EXECUTION

A. Earthwork
1. Excavation and filling are specified in Division 02 Section "Earthwork".

B. Examination
1. Examine roughing-in for plumbing piping to verify actual locations of storm drainage piping connections before sump pump installation.

C. Installation
1. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

D. Connections
1. Comply with requirements for piping specified in Division 15 Section "Storm Drainage Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.

E. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
a. Perform each visual and mechanical inspection.
b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pumps and controls will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

F. Startup Service
1. Engage a factory-authorized service representative to perform **OR** Perform, **as directed**, startup service.
a. Complete installation and startup checks according to manufacturer's written instructions.

G. Adjusting
1. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
2. Adjust control set points.

H. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 15145

Task	Specification	Specification Description
15145	02242	Piped Utilities Basic Materials And Methods
15149	02242	Piped Utilities Basic Materials And Methods
15149	02456	Water Supply Wells

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SECTION 15161 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of vibration and seismic controls for fire-suppression piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
   a. Isolation pads.
   b. Isolation mounts.
   c. Restrained elastomeric isolation mounts.
   d. Restraining braces.

C. Definitions
1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements
1. Seismic-Restraint Loading:
   a. Site Class as Defined in the IBC: A **OR** B **OR** C **OR** D **OR** E **OR** F, **as directed**.
   b. Assigned Seismic Use Group or Building Category as Defined in the IBC: I **OR** II **OR** III, **as directed**.
      1) Component Importance Factor: 1.0 **OR** 1.5, **as directed**.
      2) Component Response Modification Factor: 1.5 **OR** 2.5 **OR** 3.5 **OR** 5.0, **as directed**.
      3) Component Amplification Factor: 1.0 **OR** 2.5, **as directed.**
   c. Design Spectral Response Acceleration at Short Periods (0.2 Second): As required to meet Project requirements.
   d. Design Spectral Response Acceleration at 1-Second Period: As required to meet Project requirements.

E. Submittals
1. Product Data: For each product indicated.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.

F. Quality Assurance
1. Comply with seismic-restraint requirements in the IBC and NFPA 13 unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on

calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.2 PRODUCTS

A. Vibration Isolators
1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
   a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

B. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
   a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
3. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
4. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
5. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.
6. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
7. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

8. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

C. Factory Finishes
1. Finish
a. Manufacturer's standard prime-coat finish ready for field painting.
OR
Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1) Powder coating on springs and housings.
2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3) Baked enamel or powder coat for metal components on isolators for interior use.
4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

1.3 EXECUTION

A. Applications
1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation
1. Equipment Restraints:
a. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
b. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
2. Piping Restraints:
a. Comply with requirements in MSS SP-127 and NFPA 13.
b. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
c. Brace a change of direction longer than 12 feet (3.7 m).
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
5. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
6. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
7. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
8. Drilled-in Anchors:

a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
e. Set anchors to manufacturer's recommended torque, using a torque wrench.
f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

C. Accommodation Of Differential Seismic Motion
1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 13 Section "Wet-pipe Fire-suppression Sprinklers" for piping flexible connections.

END OF SECTION 15161

SECTION 15161a - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of vibration and seismic controls for plumbing piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Isolation pads.
b. Isolation mounts.
c. Restrained elastomeric isolation mounts.
d. Freestanding and Restrained spring isolators.
e. Housed spring mounts.
f. Elastomeric hangers.
g. Spring hangers.
h. Spring hangers with vertical-limit stops.
i. Pipe riser resilient supports.
j. Resilient pipe guides.
k. Seismic snubbers.
l. Restraining braces and cables.
m. Steel and Inertia, vibration isolation equipment bases.

C. Definitions
1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements
1. Seismic-Restraint Loading:
a. Site Class as Defined in the IBC: A **OR** B **OR** C **OR** D **OR** E **OR** F, **as directed**.
b. Assigned Seismic Use Group or Building Category as Defined in the IBC: I **OR** II **OR** III**,** as directed.
1) Component Importance Factor: 1.0 **OR** 1.5, **as directed**.
2) Component Response Modification Factor: 1.5 **OR** 2.5 **OR** 3.5 **OR** 5.0, **as directed**.
3) Component Amplification Factor: 1.0 **OR** 2.5, **as directed**.
c. Design Spectral Response Acceleration at Short Periods (0.2 Second): Percentage as directed.
d. Design Spectral Response Acceleration at 1-Second Period: Percentage as directed.

E. Submittals
1. Product Data: For each product indicated.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.
5. Field quality-control test reports.

F. Quality Assurance

1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.2 PRODUCTS

A. Vibration Isolators
1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
   a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
4. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   e. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
   f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
5. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

b. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
   a. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
   b. Base: Factory drilled for bolting to structure.
   c. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.
7. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
8. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   g. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
9. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
   a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   g. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   h. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
10. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.
11. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion

and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

B. Vibration Isolation Equipment Bases
   1. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
      a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
         1) Include supports for suction and discharge elbows for pumps.
      b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
      c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
   2. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
      a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
         1) Include supports for suction and discharge elbows for pumps.
      b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
      c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
      d. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

C. Seismic-Restraint Devices
   1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
      a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
   2. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
      a. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
      b. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
      c. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.
   3. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
   4. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
   5. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
   6. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

7. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
8. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
9. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
10. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

D. Factory Finishes
1. Finish:
a. Manufacturer's standard prime-coat finish ready for field painting.
OR
Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1) Powder coating on springs and housings.
2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3) Baked enamel or powder coat for metal components on isolators for interior use.
4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

1.3 EXECUTION

A. Applications
1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation
1. Equipment Restraints:
a. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inches (3.2 mm).
c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
2. Piping Restraints:
a. Comply with requirements in MSS SP-127.
b. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.

c. Brace a change of direction longer than 12 feet (3.7 m).

3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
5. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
6. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
7. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
8. Drilled-in Anchors:
   a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   e. Set anchors to manufacturer's recommended torque, using a torque wrench.
   f. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

C. Accommodation Of Differential Seismic Motion
1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 15 Section "Domestic Water Piping" for piping flexible connections.

D. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
   b. Schedule test with Owner before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
   c. Obtain approval before transmitting test loads to structure. Provide temporary load-spreading members.
   d. Test at least four of each type and size of installed anchors and fasteners selected.
   e. Test to 90 percent of rated proof load of device.
   f. Measure isolator restraint clearance.
   g. Measure isolator deflection.
   h. Verify snubber minimum clearances.
   i. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

j. Air-Mounting System Operational Test: Test the compressed-air leveling system.
k. Test and adjust air-mounting system controls and safeties.
l. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

3. Remove and replace malfunctioning units and retest as specified above.
4. Prepare test and inspection reports.

E. Adjusting
1. Adjust isolators after piping system is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
3. Adjust active height of sprint isolators.
4. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 15161a

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SECTION 15161b - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of vibration and seismic controls for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Isolation pads.
b. Isolation mounts.
c. Restrained elastomeric isolation mounts.
d. Freestanding and Restrained spring isolators.
e. Housed spring mounts.
f. Elastomeric hangers.
g. Spring hangers.
h. Spring hangers with vertical-limit stops.
i. Pipe riser resilient supports.
j. Resilient pipe guides.
k. Freestanding and Restrained air-mounting system.
l. Restrained vibration isolation roof-curb rails.
m. Seismic snubbers.
n. Restraining braces and cables.
o. Steel and Inertia, vibration isolation equipment bases.

C. Definitions
1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements
1. Wind-Restraint Loading:
a. Basic Wind Speed: As required to meet Project requirements.
b. Building Classification Category: I **OR** II **OR** III **OR** IV, **as directed**.
c. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
2. Seismic-Restraint Loading:
a. Site Class as Defined in the IBC: A **OR** B **OR** C **OR** D **OR** E **OR** F, **as directed**.
b. Assigned Seismic Use Group or Building Category as Defined in the IBC: I **OR** II **OR** III, **as directed**.
1) Component Importance Factor: 1.0 **OR** 1.5, **as directed**.
2) Component Response Modification Factor: 1.5 **OR** 2.5 **OR** 3.5 **OR** 5.0, **as directed**.
3) Component Amplification Factor: 1.0 **OR** 2.5, **as directed**.
c. Design Spectral Response Acceleration at Short Periods (0.2 Second): Percentage as directed.
d. Design Spectral Response Acceleration at 1-Second Period: Percentage as directed.

E. Submittals
1. Product Data: For each product indicated.

2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.
5. Field quality-control test reports.

F. Quality Assurance
1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

1.2 PRODUCTS

A. Vibration Isolators
1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
   a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
   a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
   b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
4. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   e. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).

f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

5. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   b. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
   c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
   a. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
   b. Base: Factory drilled for bolting to structure.
   c. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.
7. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
8. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
   a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
   g. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
9. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
   a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   g. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
   h. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

10. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.
11. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

B. Air-Mounting Systems
1. Air Mounts: Freestanding, single or multiple, compressed-air bellows.
   a. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
   b. Maximum Natural Frequency: 3 Hz.
   c. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).
   d. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
   e. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).
2. Restrained Air Mounts: Housed compressed-air bellows.
   a. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
   b. Maximum Natural Frequency: 3 Hz.
   c. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).
   d. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
   e. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

C. Restrained Vibration Isolation Roof-Curb Rails
1. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind, **as directed**, forces.
2. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind, **as directed**, forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches (50 mm) of rigid, glass-fiber insulation on inside of assembly.
3. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- (6-mm-) thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
   a. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind, **as directed**, restraint.
      1) Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
      2) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
      3) Minimum Additional Travel: 50 percent of the required deflection at rated load.

4) Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

b. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1) Resilient Material: Oil- and water-resistant standard neoprene **OR** natural rubber **OR** hermetically sealed compressed fiberglass, **as directed**.

4. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.
5. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

D. Vibration Isolation Equipment Bases
1. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
1) Include supports for suction and discharge elbows for pumps.
b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
2. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
a. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
1) Include supports for suction and discharge elbows for pumps.
b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
d. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

E. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
a. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
b. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
c. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.
3. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

4. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
5. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
6. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
7. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
8. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
9. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
10. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

F. Factory Finishes
1. Finish
a. Manufacturer's standard prime-coat finish ready for field painting.
OR
Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
1) Powder coating on springs and housings.
2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3) Baked enamel or powder coat for metal components on isolators for interior use.
4) Color-code or otherwise mark vibration isolation and seismic-control and wind-control, **as directed**, devices to indicate capacity range.

1.3 EXECUTION

A. Applications
1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation
1. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
2. Equipment Restraints:

a. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.

3. Piping Restraints:
   a. Comply with requirements in MSS SP-127.
   b. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
   c. Brace a change of direction longer than 12 feet (3.7 m).
4. Install cables so they do not bend across edges of adjacent equipment or building structure.
5. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
6. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
7. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
8. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
9. Drilled-in Anchors:
   a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   e. Set anchors to manufacturer's recommended torque, using a torque wrench.
   f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

C. Accommodation Of Differential Seismic Motion
1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 15 Section "Hydronic Piping" for piping flexible connections.

D. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

b. Schedule test with Owner before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
c. Obtain approval before transmitting test loads to structure. Provide temporary load-spreading members.
d. Test at least four of each type and size of installed anchors and fasteners selected.
e. Test to 90 percent of rated proof load of device.
f. Measure isolator restraint clearance.
g. Measure isolator deflection.
h. Verify snubber minimum clearances.
i. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
j. Air-Mounting System Operational Test: Test the compressed-air leveling system.
k. Test and adjust air-mounting system controls and safeties.
l. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

3. Remove and replace malfunctioning units and retest as specified above.
4. Prepare test and inspection reports.

E. Adjusting
1. Adjust isolators after piping system is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
3. Adjust air-spring leveling mechanism.
4. Adjust active height of spring isolators.
5. Adjust restraints to permit free movement of equipment within normal mode of operation.

F. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems.

END OF SECTION 15161b

Task	Specification	Specification Description
15161	02242	Piped Utilities Basic Materials And Methods

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SECTION 15162 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for expansion fittings and loops for plumbing piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Flexible-hose packless expansion joints.
b. Metal-bellows packless expansion joints.
c. Rubber packless expansion joints.
d. Grooved-joint expansion joints.
e. Pipe loops and swing connections.
f. Alignment guides and anchors.

C. Performance Requirements
1. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

D. Submittals
1. Product Data: For each type of product indicated.
2. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
b. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
c. Alignment Guide Details: Detail field assembly and attachment to building structure.
d. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
3. Welding certificates.
4. Product Certificates: For each type of expansion joint, from manufacturer.
5. Maintenance Data: For expansion joints to include in maintenance manuals.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. ASME Boiler and Pressure Vessel Code: Section IX.

1.2 PRODUCTS

A. Packless Expansion Joints
1. Flexible-Hose Packless Expansion Joints:
a. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
b. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.

c. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
   1) Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
   2) Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.

d. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
   1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
   2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.

e. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Stainless-steel fittings with threaded end connections.
   1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
   2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.

f. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Stainless-steel fittings with flanged end connections.
   1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
   2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.

g. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Stainless-steel fittings with flanged end connections.
   1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.
   2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

2. Metal-Bellows Packless Expansion Joints:
   a. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
   b. Type: Circular, corrugated bellows with external tie rods.
   c. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.
   d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
   e. Expansion Joints for Copper Tubing: Single **OR** Multi, **as directed**,-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
      1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
      2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint or threaded.
      3) End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
3. Rubber Packless Expansion Joints:

a. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
b. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.
c. Arch Type: Single **OR** Multiple, **as directed**, arches with external control rods, **as directed**.
d. Spherical Type: Single **OR** Multiple, **as directed** spheres with external control rods, **as directed**.
e. Minimum Pressure Rating for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C).
f. Minimum Pressure Rating for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C).
g. Minimum Pressure Rating for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C).
h. Material for Fluids Containing Acids, Alkalies, or Chemicals: BR **OR** CSM **OR** EPDM, **as directed**.
i. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N **OR** CR, **as directed**.
j. Material for Water: BR **OR** Buna-N **OR** CR **OR** CSM **OR** EPDM **OR** NR, **as directed**.
k. End Connections: Full-faced, integral steel flanges with steel retaining rings.

B. Grooved-Joint Expansion Joints
1. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
2. Standard: AWWA C606, for grooved joints.
3. Nipples: Galvanized, **as directed**, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
4. Couplings: Five **OR** Seven **OR** 10 **OR** 12, **as directed**, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water **OR** EPDM gasket suitable for cold and hot water, **as directed**, and bolts and nuts.

C. Alignment Guides And Anchors
1. Alignment Guides:
a. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.
2. Anchor Materials:
a. Steel Shapes and Plates: ASTM A 36/A 36M.
b. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
c. Washers: ASTM F 844, steel, plain, flat washers.
d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
1) Stud: Threaded, zinc-coated carbon steel.
2) Expansion Plug: Zinc-coated steel.
3) Washer and Nut: Zinc-coated steel.
e. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
1) Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2) Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
3) Washer and Nut: Zinc-coated steel.

1.3 EXECUTION

A. Expansion-Joint Installation
1. Install expansion joints of sizes matching sizes of piping in which they are installed.
2. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Install rubber packless expansion joints according to FSA-NMEJ-702.
4. Install grooved-joint expansion joints to grooved-end steel piping

B. Pipe Loop And Swing Connection Installation
1. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
2. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
3. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
4. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

C. Alignment-Guide And Anchor Installation
1. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
2. Install one **OR** two, **as directed**, guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
3. Attach guides to pipe and secure guides to building structure.
4. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
5. Anchor Attachments:
   a. Anchor Attachment to Black-Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   b. Anchor Attachment to Galvanized-Steel Pipe: Attach with pipe hangers. Use MSS SP-69, Type 42, riser clamp welded to anchor.
   c. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
6. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   a. Anchor Attachment to Steel Structural Members: Attach by welding.
   b. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
7. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 15162

SECTION 15162a - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for expansion fittings and loops for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Flexible, ball-joint, packed expansion joints.
b. Slip-joint packed expansion joints.
c. Expansion-compensator packless expansion joints.
d. Flexible-hose packless expansion joints.
e. Metal-bellows packless expansion joints.
f. Rubber packless expansion joints.
g. Grooved-joint expansion joints.
h. Pipe loops and swing connections.
i. Alignment guides and anchors.

C. Performance Requirements
1. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

D. Submittals
1. Product Data: For each type of product indicated.
2. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
b. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
c. Alignment Guide Details: Detail field assembly and attachment to building structure.
d. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
3. Welding certificates.
4. Product Certificates: For each type of expansion joint, from manufacturer.
5. Maintenance Data: For expansion joints to include in maintenance manuals.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
b. ASME Boiler and Pressure Vessel Code: Section IX.

1.2 PRODUCTS

A. Packed Expansion Joints
1. Flexible, Ball-Joint, Packed Expansion Joints:

a. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; and ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
b. Material: Carbon-steel assembly with asbestos-free composition packing.
c. Design: For 360-degree rotation and angular deflection.
d. Minimum Pressure Rating: 250 psig at 400 deg F (1725 kPa at 204 deg C).
e. Angular Deflection for NPS 6 (DN 150) and Smaller: 30 degree minimum.
f. Angular Deflection for NPS 8 (DN 200) and Larger: 15 degree minimum.
g. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
h. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

2. Slip-Joint Packed Expansion Joints:
   a. Standard: ASTM F 1007.
   b. Material: Carbon steel with asbestos-free PTFE packing.
   c. Design: With internal guide and injection device for repacking under pressure. Include drip connection if used for steam piping.
   d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
   e. End Connections: Flanged or weld ends to match piping system.

B. Packless Expansion Joints
1. Metal, Expansion-Compensator Packless Expansion Joints:
   a. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.
   b. Configuration for Copper Tubing: Two-ply, phosphor-bronze bellows with copper pipe ends.
      1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
      2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.
   c. Configuration for Steel Piping: Two-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
      1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
      2) End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged **OR** Weld, **as directed**.
2. Rubber, Expansion-Compensator Packless Expansion Joints:
   a. Material: Twin reinforced-rubber spheres with external restraining cables.
   b. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C) unless otherwise indicated.
   c. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
3. Flexible-Hose Packless Expansion Joints:
   a. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
   b. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
   c. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
      1) Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
      2) Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
   d. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
      1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.

2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.

e. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.

1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.

2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.

f. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.

1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.

2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.

g. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.

1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.

2) Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

h. Expansion Joints for Steel Piping NPS 14 (DN 350) and Larger: Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.

1) Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.

4. Metal-Bellows Packless Expansion Joints:

a. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."

b. Type: Circular, corrugated bellows with external tie rods.

c. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.

d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.

e. Expansion Joints for Copper Tubing: Single **OR** Multi, **as directed**,-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.

1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.

2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint or threaded.

3) End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.

f. Expansion Joints for Steel Piping: Single **OR** Multi, **as directed**,-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.

1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.

2) End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: Flanged **OR** Weld, **as directed**.

5. Rubber Packless Expansion Joints:

a. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

b. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.

c. Arch Type: Single **OR** Multiple, **as directed**, arches with external control rods, **as directed**.
d. Spherical Type: Single **OR** Multiple, **as directed**, spheres with external control rods, **as directed**.
e. Minimum Pressure Rating for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C).
f. Minimum Pressure Rating for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C).
g. Minimum Pressure Rating for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C).
h. Material for Fluids Containing Acids, Alkalies, or Chemicals: BR **OR** CSM **OR** EPDM, **as directed**.
i. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N **OR** CR, **as directed**.
j. Material for Water: BR **OR** Buna-N **OR** CR **OR** CSM **OR** EPDM **OR** NR, **as directed**.
k. End Connections: Full-faced, integral steel flanges with steel retaining rings.

C. Grooved-Joint Expansion Joints
1. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
2. Standard: AWWA C606, for grooved joints.
3. Nipples: Galvanized, **as directed**, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
4. Couplings: Five **OR** Seven **OR** 10 **OR** 12, **as directed**, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water **OR** EPDM gasket suitable for cold and hot water, **as directed**, and bolts and nuts.

D. Alignment Guides And Anchors
1. Alignment Guides:
a. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.
2. Anchor Materials:
a. Steel Shapes and Plates: ASTM A 36/A 36M.
b. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
c. Washers: ASTM F 844, steel, plain, flat washers.
d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
1) Stud: Threaded, zinc-coated carbon steel.
2) Expansion Plug: Zinc-coated steel.
3) Washer and Nut: Zinc-coated steel.
e. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
1) Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2) Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
3) Washer and Nut: Zinc-coated steel.

1.3 EXECUTION

A. Expansion-Joint Installation
1. Install expansion joints of sizes matching sizes of piping in which they are installed.

2. Install packed-type expansion joints with packing suitable for fluid service.
3. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
4. Install rubber packless expansion joints according to FSA-NMEJ-702.
5. Install grooved-joint expansion joints to grooved-end steel piping

B. Pipe Loop And Swing Connection Installation
1. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
2. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
3. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
4. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

C. Alignment-Guide And Anchor Installation
1. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
2. Install one **OR** two, **as directed**, guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
3. Attach guides to pipe and secure guides to building structure.
4. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
5. Anchor Attachments:
   a. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   b. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
6. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
   a. Anchor Attachment to Steel Structural Members: Attach by welding.
   b. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
7. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 15162a

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Task	Specification	Specification Description
15164	01352	No Specification Required
15164	02242	Piped Utilities Basic Materials And Methods
15164	15061f	Hydronic Piping
15164	15061g	Steam And Condensate Piping
15164	15061h	Refrigerant Piping
15164	15061j	General-Service Compressed-Air Piping
15173	02242	Piped Utilities Basic Materials And Methods
15173	15083	Hydronic Pumps
15174	02242	Piped Utilities Basic Materials And Methods
15174	15064a	Underground Storage Tanks
15176	01352	No Specification Required
15176	02242	Piped Utilities Basic Materials And Methods
15176	15064a	Underground Storage Tanks
15176	15061f	Hydronic Piping
15177	02242	Piped Utilities Basic Materials And Methods
15177	15064a	Underground Storage Tanks
15179	02242	Piped Utilities Basic Materials And Methods

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SECTION 15182 - FIRE-SUPPRESSION SYSTEMS INSULATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for fire-suppression systems insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Insulation Materials:
1) Calcium silicate.
2) Cellular glass.
3) Flexible elastomeric.
4) Mineral fiber.
5) Phenolic.
6) Polyisocyanurate.
7) Polyolefin.
8) Polystyrene.
b. Insulating cements.
c. Adhesives.
d. Mastics.
e. Lagging adhesives.
f. Sealants.
g. Factory-applied jackets.
h. Field-applied fabric-reinforcing mesh.
i. Field-applied cloths.
j. Field-applied jackets.
k. Tapes.
l. Securements.
m. Corner angles.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
b. Detail attachment and covering of heat tracing inside insulation.
c. Detail insulation application at pipe expansion joints for each type of insulation.
d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
e. Detail removable insulation at piping specialties and equipment connections.
f. Detail application of field-applied jackets.
g. Detail application at linkages of control devices.
h. Detail field application for fire-suppression water storage tanks.
4. Field quality-control reports.

D. Quality Assurance

1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Delivery, Storage, And Handling
1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.2 PRODUCTS

A. Insulation Materials
1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
6. Calcium Silicate:
   a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   b. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   a. Block Insulation: ASTM C 552, Type I.
   b. Special-Shaped Insulation: ASTM C 552, Type III.
   c. Board Insulation: ASTM C 552, Type IV.
   d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
   f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
10. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
11. Mineral-Fiber, Preformed Pipe Insulation:
   a. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied

jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

b. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

12. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

13. Phenolic:

a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.

b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.

c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.

2) Board for Equipment Applications: None **OR** ASJ, **as directed**.

14. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.

b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.

c. Fabricate shapes according to ASTM C 450 and ASTM C 585.

d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.

2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.

15. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

16. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

B. Insulating Cements

1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

C. Adhesives

1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mastics
1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
   a. For indoor applications, use mastics that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
   b. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
   d. Color: White.
3. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
   b. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
   c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   d. Color: White.
4. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   b. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
   c. Solids Content: 63 percent by volume and 73 percent by weight.
   d. Color: White.

E. Lagging Adhesives
1. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   a. For indoor applications, use lagging adhesives that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
   c. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
   d. Color: White.

F. Sealants
1. Joint Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Permanently flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   d. Color: White or gray.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. FSK and Metal Jacket Flashing Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Fire- and water-resistant, flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   d. Color: Aluminum.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Fire- and water-resistant, flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   d. Color: White.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Factory-Applied Jackets
1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   d. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   e. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
   f. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

H. Field-Applied Fabric-Reinforcing Mesh
1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
2. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave.

I. Field-Applied Cloths
1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

J. Field-Applied Jackets
1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
2. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   a. Adhesive: As recommended by jacket material manufacturer.
   b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
   c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   d. Factory-fabricated tank heads and tank side panels.
3. Metal Jacket:
   a. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
      1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
      2) Finish and thickness are indicated in field-applied jacket schedules.
      3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      5) Factory-Fabricated Fitting Covers:
         a) Same material, finish, and thickness as jacket.
         b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         c) Tee covers.
         d) Flange and union covers.
         e) End caps.
         f) Beveled collars.
         g) Valve covers.
         h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
   b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
      1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
      2) Material, finish, and thickness are indicated in field-applied jacket schedules.
      3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      5) Factory-Fabricated Fitting Covers:
         a) Same material, finish, and thickness as jacket.
         b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         c) Tee covers.
         d) Flange and union covers.
         e) End caps.
         f) Beveled collars.
         g) Valve covers.
         h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

K. Tapes

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   a. Width: 3 inches (75 mm).
   b. Thickness: 11.5 mils (0.29 mm).
   c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   d. Elongation: 2 percent.
   e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   a. Width: 3 inches (75 mm).
   b. Thickness: 6.5 mils (0.16 mm).
   c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   d. Elongation: 2 percent.
   e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   a. Width: 2 inches (50 mm).
   b. Thickness: 6 mils (0.15 mm).
   c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   d. Elongation: 500 percent.
   e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   a. Width: 2 inches (50 mm).
   b. Thickness: 3.7 mils (0.093 mm).
   c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   d. Elongation: 5 percent.
   e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   a. Width: 3 inches (75 mm).
   b. Film Thickness: 4 mils (0.10 mm).
   c. Adhesive Thickness: 1.5 mils (0.04 mm).
   d. Elongation at Break: 145 percent.
   e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.
6. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   a. Width: 3 inches (75 mm).
   b. Film Thickness: 6 mils (0.15 mm).
   c. Adhesive Thickness: 1.5 mils (0.04 mm).
   d. Elongation at Break: 145 percent.
   e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

L. Securements
1. Bands:
   a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
   b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
   c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
2. Insulation Pins and Hangers:
   a. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in

position indicated when self-locking washer is in place. Comply with the following requirements:

1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

b. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

1) Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
3) Adhesive-backed base with a peel-off protective cover.

c. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
4. Wire: 0.080-inch (2.0-mm) nickel-copper alloy **OR** 0.062-inch (1.6-mm) soft-annealed, stainless steel **OR** 0.062-inch (1.6-mm) soft-annealed, galvanized steel, **as directed**.

1.3 EXECUTION

A. Preparation

1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

   OR

   Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

   a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

B. General Installation Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.

2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
    a. Install insulation continuously through hangers and around anchor attachments.
    b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
    c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
    d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
12. Install insulation with factory-applied jackets as follows:
    a. Draw jacket tight and smooth.
    b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
    c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
        1) For below ambient services, apply vapor-barrier mastic over staples.
    d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
    e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
16. For above ambient services, do not install insulation to the following:
    a. Vibration-control devices.
    b. Testing agency labels and stamps.
    c. Nameplates and data plates.
    d. Manholes.
    e. Handholes.
    f. Cleanouts.

C. Penetrations

1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
   a. Seal penetrations with flashing sealant.
   b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
   d. Seal jacket to roof flashing with flashing sealant.
2. Insulation Installation at Below-Grade Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
   a. Seal penetrations with flashing sealant.
   b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
   c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
   d. Seal jacket to wall flashing with flashing sealant.
4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   a. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems" for firestopping and fire-resistive joint sealers.
6. Insulation Installation at Floor Penetrations:
   a. Pipe: Install insulation continuously through floor penetrations.
   b. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

D. Equipment, Tank, And Vessel Insulation Installation
1. Secure insulation with adhesive and anchor pins and speed washers.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
   b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   c. Protect exposed corners with secured corner angles.
   d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      1) Do not weld anchor pins to ASME-labeled pressure vessels.
      2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      3) On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
      4) Do not overcompress insulation during installation.
      5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
      6) Impale insulation over anchor pins and attach speed washers.
      7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
g. Stagger joints between insulation layers at least 3 inches (75 mm).
h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
b. Seal longitudinal seams and end joints.

E. General Pipe Insulation Installation
1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for

above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

4. Install removable insulation covers at locations indicated. Installation shall conform to the following:

a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

b. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

F. Calcium Silicate Insulation Installation

1. Insulation Installation on Straight Pipes and Tubes:

a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.

b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

2. Insulation Installation on Pipe Flanges:

a. Install preformed pipe insulation to outer diameter of pipe flange.

b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

d. Finish flange insulation same as pipe insulation.

3. Insulation Installation on Pipe Fittings and Elbows:

a. Install preformed sections of same material as straight segments of pipe insulation when available.

b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
c. Finish fittings insulation same as pipe insulation.

4. Insulation Installation on Valves and Pipe Specialties:
a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
b. Install insulation to flanges as specified for flange insulation application.
c. Finish valve and specialty insulation same as pipe insulation.

G. Cellular-Glass Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges:
a. Install preformed pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
a. Install preformed sections of same material as straight segments of pipe insulation when available.
b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
a. Install preformed sections of cellular-glass insulation to valve body.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

H. Flexible Elastomeric Insulation Installation
1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges:
a. Install pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
3. Insulation Installation on Pipe Fittings and Elbows:
a. Install mitered sections of pipe insulation.
b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed valve covers manufactured of same material as pipe insulation when available.
   b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.
   d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

I. Mineral-Fiber Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
   c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   d. Install insulation to flanges as specified for flange insulation application.

J. Phenolic Insulation Installation
1. General Installation Requirements:
   a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
   b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
2. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.

b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and applicable insulation joint sealant.
c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

3. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed insulation sections of same material as straight segments of pipe insulation.
5. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed insulation sections of same material as straight segments of pipe insulation.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

K. Polyisocyanurate Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
   b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
3. Insulation Installation on Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of polyisocyanurate insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

L. Polyolefin Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges:
   a. Install pipe insulation to outer diameter of pipe flange.

b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install mitered sections of polyolefin pipe insulation.
   b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.
   d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

M. Polystyrene Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
   b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed insulation sections of same material as straight segments of pipe insulation.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed section of polystyrene insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

N. Field-Applied Jacket Installation
1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   a. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
   b. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
   c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
   a. Draw jacket material smooth and tight.
   b. Install lap or joint strips with same material as jacket.

c. Secure jacket to insulation with manufacturer's recommended adhesive.
d. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

3. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
   a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
4. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
5. Where PVDC jackets are indicated, install as follows:
   a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
   b. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
   c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
   d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
   e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

O. Finishes
1. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
   a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
      1) Finish Coat Material: Interior, flat, latex-emulsion size.
2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
4. Do not field paint aluminum or stainless-steel jackets.

P. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
   b. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of

inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

Q. Equipment Insulation Schedule
1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
3. Fire-suppression water storage tank insulation shall be one of the following:
   a. Cellular Glass: 2 inches (50 mm) thick.
   b. Flexible Elastomeric: 1 inch (25 mm) thick.
   c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
   e. Phenolic: 1 inch (25 mm) thick.
   f. Polyisocyanurate: 1 inch (25 mm) thick.
   g. Polyolefin: 1 inch (25 mm) thick.

R. Piping Insulation Schedule, General
1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
   a. Indoor fire-suppression piping.
   b. Underground piping.

S. Indoor Piping Insulation Schedule
1. Indoor Engine Coolant Piping for Remote Radiator of Engine-Driven Fire Pump:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Calcium Silicate: 2 inches (50 mm) thick.
      2) Cellular Glass: 2 inches (50 mm) thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches (50 mm) thick.
2. Indoor Engine Exhaust Piping and Silencer, All Pipe Sizes: Calcium silicate, 4 inches (100 mm) thick.

T. Outdoor, Aboveground Piping Insulation Schedule
1. Outdoor Engine Coolant Piping for Remote Radiator of Engine-Driven Fire Pump:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Calcium Silicate: 2 inches (50 mm) thick.
      2) Cellular Glass: 2 inches (50 mm) thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 2 inches (50 mm) thick.
2. Outdoor Engine Exhaust Piping and Silencer, All Pipe Sizes: Calcium silicate, 4 inches (100 mm) thick.
3. Outdoor Fire-Suppression Piping Filled with Water:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 2 inches (50 mm) thick.
      2) Flexible Elastomeric: 2 inches (50 mm) thick.
      3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
      4) Phenolic: 2 inches (50 mm) thick.
      5) Polyisocyanurate: 2 inches (50 mm) thick.
      6) Polyolefin: 2 inches (50 mm) thick.
      7) Polystyrene: 2 inches (50 mm) thick.

U. Indoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Piping, Concealed:
   a. None.
   b. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   c. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   d. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Piping, Exposed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

V. Outdoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Equipment, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
   a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

5. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
   a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Outdoor Exposed Piping:
   a. PVC: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm) **OR** 40 mils (1.0 mm), **as directed**, thick.
   b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, ,**as directed** with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

END OF SECTION 15182

SECTION 15182a - PLUMBING INSULATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for plumbing insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Insulation Materials:
1) Calcium silicate.
2) Cellular glass.
3) Flexible elastomeric.
4) Mineral fiber.
5) Phenolic.
6) Polyisocyanurate.
7) Polyolefin.
8) Polystyrene.
b. Insulating cements.
c. Adhesives.
d. Mastics.
e. Lagging adhesives.
f. Sealants.
g. Factory-applied jackets.
h. Field-applied fabric-reinforcing mesh.
i. Field-applied cloths.
j. Field-applied jackets.
k. Tapes.
l. Securements.
m. Corner angles.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
b. Detail attachment and covering of heat tracing inside insulation.
c. Detail insulation application at pipe expansion joints for each type of insulation.
d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
e. Detail removable insulation at piping specialties, equipment connections, and access panels.
f. Detail application of field-applied jackets.
g. Detail application at linkages of control devices.
h. Detail field application for each equipment type.
4. Field quality-control reports.

D. Quality Assurance

1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
   a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Delivery, Storage, And Handling
1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.2 PRODUCTS

A. Insulation Materials
1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
6. Calcium Silicate:
   a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   b. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
   c. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   a. Block Insulation: ASTM C 552, Type I.
   b. Special-Shaped Insulation: ASTM C 552, Type III.
   c. Board Insulation: ASTM C 552, Type IV.
   d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
   e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
   f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
10. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.
11. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For equipment applications, provide insulation

without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

12. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
13. Mineral-Fiber, Preformed Pipe Insulation:
    a. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
14. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
15. Phenolic:
    a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
    b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
    c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
    d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
        1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.
        2) Board for Equipment Applications: None **OR** ASJ, **as directed**.
16. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
    a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
    b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
    c. Fabricate shapes according to ASTM C 450 and ASTM C 585.
    d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
        1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
        2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
17. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
18. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

B. Insulating Cements
1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

C. Adhesives
1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Mastics
1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
   a. For indoor applications, use mastics that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
   b. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
   c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
   d. Color: White.
3. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
   b. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
   c. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
   d. Color: White.
4. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
   b. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
   c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   d. Color: White.
5. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   b. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
   c. Solids Content: 63 percent by volume and 73 percent by weight.
   d. Color: White.

E. Lagging Adhesives

1. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
   a. For indoor applications, use lagging adhesives that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
   c. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
   d. Color: White.

F. Sealants
1. Joint Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Permanently flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   d. Color: White or gray.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. FSK and Metal Jacket Flashing Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Fire- and water-resistant, flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   d. Color: Aluminum.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Fire- and water-resistant, flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   d. Color: White.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

G. Factory-Applied Jackets
1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   d. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   e. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
   f. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

H. Field-Applied Fabric-Reinforcing Mesh
1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.

2. Woven Glass-Fiber Fabric for Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment and pipe.

I. Field-Applied Cloths
1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

J. Field-Applied Jackets
1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
2. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   a. Adhesive: As recommended by jacket material manufacturer.
   b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
   c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   d. Factory-fabricated tank heads and tank side panels.
3. Metal Jacket:
   a. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
      1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
      2) Finish and thickness are indicated in field-applied jacket schedules.
      3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      5) Factory-Fabricated Fitting Covers:
         a) Same material, finish, and thickness as jacket.
         b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
         c) Tee covers.
         d) Flange and union covers.
         e) End caps.
         f) Beveled collars.
         g) Valve covers.
         h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
   b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
      1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
      2) Material, finish, and thickness are indicated in field-applied jacket schedules.
      3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
      5) Factory-Fabricated Fitting Covers:

a) Same material, finish, and thickness as jacket.
b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
c) Tee covers.
d) Flange and union covers.
e) End caps.
f) Beveled collars.
g) Valve covers.
h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

4. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

K. Tapes

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   a. Width: 3 inches (75 mm).
   b. Thickness: 11.5 mils (0.29 mm).
   c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   d. Elongation: 2 percent.
   e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   a. Width: 3 inches (75 mm).
   b. Thickness: 6.5 mils (0.16 mm).
   c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   d. Elongation: 2 percent.
   e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   a. Width: 2 inches (50 mm).
   b. Thickness: 6 mils (0.15 mm).
   c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   d. Elongation: 500 percent.
   e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   a. Width: 2 inches (50 mm).
   b. Thickness: 3.7 mils (0.093 mm).
   c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   d. Elongation: 5 percent.
   e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape: White vapor-retarder PVDC tape with acrylic adhesive.
   a. Width: 3 inches (75 mm).
   b. Film Thickness: 4 mils (0.10 mm) **OR** 6 mils (0.15 mm), **as directed**.
   c. Adhesive Thickness: 1.5 mils (0.04 mm).
   d. Elongation at Break: 145 percent.
   e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

L. Securements

1. Bands:
   a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.

b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.

c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

2. Insulation Pins and Hangers:

a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated.

b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

d. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

1) Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.

2) Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).

3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

1) Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.

3) Adhesive-backed base with a peel-off protective cover.

f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

g. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
4. Wire: 0.080-inch (2.0-mm) nickel-copper alloy **OR** 0.062-inch (1.6-mm) soft-annealed, stainless steel **OR** 0.062-inch (1.6-mm) soft-annealed, galvanized steel, **as directed**.

M. Corner Angles
1. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
2. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.
3. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**.

1.3 EXECUTION

A. Preparation
1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
OR
Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

B. General Installation Requirements
1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
a. Install insulation continuously through hangers and around anchor attachments.

b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
12. Install insulation with factory-applied jackets as follows:
    a. Draw jacket tight and smooth.
    b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
    c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
        1) For below ambient services, apply vapor-barrier mastic over staples.
    d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
    e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
16. For above ambient services, do not install insulation to the following:
    a. Vibration-control devices.
    b. Testing agency labels and stamps.
    c. Nameplates and data plates.
    d. Manholes.
    e. Handholes.
    f. Cleanouts.

C. Penetrations
1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
    a. Seal penetrations with flashing sealant.
    b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
    d. Seal jacket to roof flashing with flashing sealant.
2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
    a. Seal penetrations with flashing sealant.

b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
d. Seal jacket to wall flashing with flashing sealant.

4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
   a. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems" for firestopping and fire-resistive joint sealers.
6. Insulation Installation at Floor Penetrations:
   a. Pipe: Install insulation continuously through floor penetrations.
   b. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

D. Equipment, Tank, And Vessel Insulation Installation
1. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
   b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   c. Protect exposed corners with secured corner angles.
   d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      1) Do not weld anchor pins to ASME-labeled pressure vessels.
      2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      3) On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
      4) Do not overcompress insulation during installation.
      5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
      6) Impale insulation over anchor pins and attach speed washers.
      7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
   e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
   f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
   g. Stagger joints between insulation layers at least 3 inches (75 mm).
   h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   b. Seal longitudinal seams and end joints.
3. Insulation Installation on Pumps:
   a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   b. Fabricate boxes from galvanized steel **OR** aluminum **OR** stainless steel, **as directed**, at least 0.040 inch (1.0 mm) **OR** 0.050 inch (1.3 mm) **OR** 0.060 inch (1.6 mm), **as directed**, thick.
   c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

E. General Pipe Insulation Installation
1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
   b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
   f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
   g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.

h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

4. Install removable insulation covers at locations indicated. Installation shall conform to the following:

a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

b. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

F. Calcium Silicate Insulation Installation

1. Insulation Installation on Domestic Water Boiler Breechings:

a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation material.

b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

c. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

2. Insulation Installation on Straight Pipes and Tubes:

a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.

b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

3. Insulation Installation on Pipe Flanges:

a. Install preformed pipe insulation to outer diameter of pipe flange.

b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
d. Finish flange insulation same as pipe insulation.

4. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
   c. Finish fittings insulation same as pipe insulation.
5. Insulation Installation on Valves and Pipe Specialties:
   a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   b. Install insulation to flanges as specified for flange insulation application.
   c. Finish valve and specialty insulation same as pipe insulation.

G. Cellular-Glass Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of cellular-glass insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

H. Flexible Elastomeric Insulation Installation
1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges:
   a. Install pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install mitered sections of pipe insulation.
   b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed valve covers manufactured of same material as pipe insulation when available.
   b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.
   d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

I. Mineral-Fiber Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   d. Install insulation to flanges as specified for flange insulation application.

J. Phenolic Insulation Installation
1. General Installation Requirements:

a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

2. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
5. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

K. Polyisocyanurate Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
   b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
3. Insulation Installation on Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of polyisocyanurate insulation to valve body.

b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

L. Polyolefin Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges:
a. Install pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
3. Insulation Installation on Pipe Fittings and Elbows:
a. Install mitered sections of polyolefin pipe insulation.
b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation Installation on Valves and Pipe Specialties:
a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.
d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

M. Polystyrene Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
a. Install preformed pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
a. Install preformed section of polystyrene insulation to valve body.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

N. Field-Applied Jacket Installation
1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   a. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
   b. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
   c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
   a. Draw jacket material smooth and tight.
   b. Install lap or joint strips with same material as jacket.
   c. Secure jacket to insulation with manufacturer's recommended adhesive.
   d. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
   e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
3. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
4. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
5. Where PVDC jackets are indicated, install as follows:
   a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
   b. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
   c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
   d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
   e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

O. Finishes
1. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
   a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
      1) Finish Coat Material: Interior, flat, latex-emulsion size.
2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
4. Do not field paint aluminum or stainless-steel jackets.

P. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
   b. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

Q. Domestic Water Boiler Breeching Insulation Schedule
1. Round, exposed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
2. Round, concealed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
3. Rectangular, exposed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
4. Rectangular, concealed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.

R. Equipment Insulation Schedule
1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
3. Heat-exchanger (water-to-water for domestic water heating service) insulation shall be one of the following:
   a. Calcium Silicate: 3 inches (75 mm) thick.
   b. Cellular Glass: 3 inches (75 mm) thick.
   c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
4. Steam-to-hot-water converter insulation shall be one of the following:
   a. Calcium Silicate: 3 inches (75 mm) thick.

b. Cellular Glass: 3 inches (75 mm) thick.
c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

5. Domestic water pump insulation shall be one of the following:
   a. Cellular Glass: 2 inches (50 mm) thick.
   b. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1 inch (25 mm) thick.
   d. Polyisocyanurate: 1 inch (25 mm) thick.
6. Domestic chilled-water (potable) pump insulation shall be one of the following:
   a. Cellular Glass: 3 inches (75 mm) thick.
   b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1 inch (25 mm) thick.
   d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
7. Domestic hot-water pump insulation shall be one of the following:
   a. Cellular Glass: 2 inches (50 mm) thick.
   b. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1 inch (25 mm) thick.
   d. Polyisocyanurate: 1 inch (25 mm) thick.
8. Domestic water, domestic chilled-water (potable), and domestic hot-water hydropneumatic tank insulation shall be one of the following:
   a. Cellular Glass: 1-1/2 inches (38 mm) thick.
   b. Flexible Elastomeric: 1 inch (25 mm) thick.
   c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
   e. Phenolic: 1 inch (25 mm) thick.
   f. Polyisocyanurate: 1 inch (25 mm) thick.
   g. Polyolefin: 1 inch (25 mm) thick.
9. Domestic hot-water storage tank insulation shall be one of the following, of thickness to provide an R-value of 12.5:
   a. Cellular glass.
   b. Mineral-Fiber Board: 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Mineral-fiber pipe and tank.
   d. Phenolic.
10. Domestic water storage tank insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
11. Domestic chilled-water (potable) storage tank insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.

f. Polyisocyanurate: 1 inch (25 mm) thick.
g. Polyolefin: 1 inch (25 mm) thick.

12. Piping system filter-housing insulation shall be one of the following:
    a. Cellular Glass: 3 inches (75 mm) thick.
    b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

S. Piping Insulation Schedule, General
1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
    a. Drainage piping located in crawl spaces.
    b. Underground piping.
    c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

T. Indoor Piping Insulation Schedule
1. Domestic Cold Water:
    a. NPS 1 (DN 25) and Smaller: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
        4) Phenolic: 1 inch (25 mm) thick.
        5) Polyisocyanurate: 1 inch (25 mm) thick.
        6) Polyolefin: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
    b. NPS 1-1/4 (DN 32) and Larger: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 1 inch (25 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
        4) Phenolic: 1 inch (25 mm) thick.
        5) Polyisocyanurate: 1 inch (25 mm) thick.
        6) Polyolefin: 1 inch (25 mm) thick.
2. Domestic Hot and Recirculated Hot Water:
    a. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
        4) Phenolic: 1 inch (25 mm) thick.
        5) Polyisocyanurate: 1 inch (25 mm) thick.
        6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
    b. NPS 1-1/2 (DN 40) and Larger: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 1 inch (25 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
        4) Phenolic: 1 inch (25 mm) thick.
        5) Polyisocyanurate: 1 inch (25 mm) thick.
        6) Polyolefin: 1 inch (25 mm) thick.
3. Domestic Chilled Water (Potable):
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 1 inch (25 mm) thick.

3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
4) Phenolic: 1 inch (25 mm) thick.
5) Polyisocyanurate: 1 inch (25 mm) thick.
6) Polyolefin: 1 inch (25 mm) thick.

4. Stormwater and Overflow:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) thick.
      2) Flexible Elastomeric: 1 inch (25 mm) thick.
      3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
      4) Phenolic: 1 inch (25 mm) thick.
      5) Polyisocyanurate: 1 inch (25 mm) thick.
      6) Polyolefin: 1 inch (25 mm) thick.
5. Roof Drain and Overflow Drain Bodies:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) thick.
      2) Flexible Elastomeric: 1 inch (25 mm) thick.
      3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
      4) Phenolic: 1 inch (25 mm) thick.
      5) Polyisocyanurate: 1 inch (25 mm) thick.
      6) Polyolefin: 1 inch (25 mm) thick.
6. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Flexible Elastomeric: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
      2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm) thick.
      3) Polyolefin: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) thick.
7. Sanitary Waste Piping Where Heat Tracing Is Installed:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 2 inches (50 mm) thick.
      2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches (38 mm) thick.
      3) Phenolic: 1-1/2 inches (38 mm) thick.
      4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
8. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) thick.
      2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
      4) Phenolic: 1 inch (25 mm) thick.
      5) Polyisocyanurate: 1 inch (25 mm) thick.
      6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
9. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet (3 m) of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) thick.
      2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
      4) Phenolic: 1 inch (25 mm) thick.
      5) Polyisocyanurate: 1 inch (25 mm) thick.
      6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
10. Hot Service Drains:
   a. All Pipe Sizes: Insulation shall be one of the following:

1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
2) Cellular Glass: 1-1/2 inches (38 mm) thick.
3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.

11. Hot Service Vents:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
        2) Cellular Glass: 1-1/2 inches (38 mm) thick.
        3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.

U. Outdoor, Aboveground Piping Insulation Schedule
1. Domestic Water Piping:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 2 inches (50 mm) thick.
        2) Flexible Elastomeric: 2 inches (50 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
        4) Phenolic: 2 inches (50 mm) thick.
        5) Polyisocyanurate: 2 inches (50 mm) thick.
        6) Polyolefin: 2 inches (50 mm) thick.
        7) Polystyrene: 2 inches (50 mm) thick.
2. Domestic Hot and Recirculated Hot Water:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 2 inches (50 mm) thick.
        2) Flexible Elastomeric: 2 inches (50 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
        4) Phenolic: 2 inches (50 mm) thick.
        5) Polyisocyanurate: 2 inches (50 mm) thick.
        6) Polyolefin: 2 inches (50 mm) thick.
3. Sanitary Waste Piping Where Heat Tracing Is Installed:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 2 inches (50 mm) thick.
        2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
        3) Phenolic: 2 inches (50 mm) thick.
        4) Polyisocyanurate: 2 inches (50 mm) thick.
4. Hot Service Drains:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
        2) Cellular Glass: 1-1/2 inches (38 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
5. Hot Service Vents:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
        2) Cellular Glass: 1-1/2 inches (38 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type II: 1 inch (25 mm) thick.

V. Outdoor, Underground Piping Insulation Schedule
1. Loose-fill insulation, for belowground piping, is specified in Division 02.
2. Sanitary Waste Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches (50 mm) thick.
3. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.

W. Indoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Equipment, Concealed:
    a. None.

b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

4. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
   a. None.
   b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Piping, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Piping, Exposed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.

c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
d. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

X. Outdoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Equipment, Concealed:
a. None.
b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
d. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed** with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Piping, Concealed:
a. None.
b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.

d. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.

e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

7. Piping, Exposed:

a. PVC: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm) **OR** 40 mils (1.0 mm), **as directed**, thick.

b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.

c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, ,**as directed,** with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

Y. Underground, Field-Installed Insulation Jacket

1. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 15182a

Task	Specification	Specification Description
15185	02456b	Steam Distribution
15186	15182	Fire-Suppression Systems Insulation
15186	15182a	Plumbing Insulation

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SECTION 15190 - HVAC INSULATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for HVAC insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Insulation Materials:
1) Calcium silicate.
2) Cellular glass.
3) Flexible elastomeric.
4) Mineral fiber.
5) Phenolic.
6) Polyisocyanurate.
7) Polyolefin.
8) Polystyrene.
b. Fire-rated insulation systems.
c. Insulating cements.
d. Adhesives.
e. Mastics.
f. Lagging adhesives.
g. Sealants.
h. Factory-applied jackets.
i. Field-applied fabric-reinforcing mesh.
j. Field-applied cloths.
k. Field-applied jackets.
l. Tapes.
m. Securements.
n. Corner angles.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
b. Detail attachment and covering of heat tracing inside insulation.
c. Detail insulation application at pipe expansion joints for each type of insulation.
d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
e. Detail removable insulation at piping specialties, equipment connections, and access panels.
f. Detail application of field-applied jackets.
g. Detail application at linkages of control devices.
h. Detail field application for each equipment type.
4. Field quality-control reports.

D. Quality Assurance
   1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
      a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
      b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

E. Delivery, Storage, And Handling
   1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.2 PRODUCTS

A. Insulation Materials
   1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
   2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
   3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
   4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
   5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
   6. Calcium Silicate:
      a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
      b. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
      c. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
   7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
      a. Block Insulation: ASTM C 552, Type I.
      b. Special-Shaped Insulation: ASTM C 552, Type III.
      c. Board Insulation: ASTM C 552, Type IV.
      d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
      e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
      f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
   8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I **OR** II with factory-applied vinyl jacket **OR** III with factory-applied FSK jacket **OR** III with factory-applied FSP jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   10. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

11. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. For equipment applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
12. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
13. Mineral-Fiber, Preformed Pipe Insulation:
    a. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
    b. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
14. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.
15. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
16. Phenolic:
    a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
    b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
    c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
    d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
        1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.
        2) Board for Duct and Plenum Applications: None **OR** ASJ, **as directed**.
        3) Board for Equipment Applications: None **OR** ASJ, **as directed**.
17. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
    a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
    b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches (38 mm) as tested by ASTM E 84.
    c. Fabricate shapes according to ASTM C 450 and ASTM C 585.
    d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
        1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
        2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
18. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
19. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed

0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

B. Fire-Rated Insulation Systems
1. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C 656, Type II, Grade 6. tested and certified to provide a 1-hour **OR** 2-hour, **as directed**, fire rating by a NRTL acceptable to authority having jurisdiction.
2. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1-hour **OR** 2-hour, **as directed**, fire rating by a NRTL acceptable to authority having jurisdiction.

C. Insulating Cements
1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

D. Adhesives
1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Mastics
1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
   a. For indoor applications, use mastics that have an approved VOC content or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.

b. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
d. Color: White.

3. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
   b. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
   c. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
   d. Color: White.
4. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
   b. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
   c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
   d. Color: White.
5. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
   a. Water-Vapor Permeance: ASTM F 1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   b. Service Temperature Range: Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).
   c. Solids Content: 63 percent by volume and 73 percent by weight.
   d. Color: White.

F. Lagging Adhesives
1. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   a. For indoor applications, use lagging adhesives that have an approved VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
   c. Service Temperature Range: Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).
   d. Color: White.

G. Sealants
1. Joint Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Permanently flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
   d. Color: White or gray.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. FSK and Metal Jacket Flashing Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Fire- and water-resistant, flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   d. Color: Aluminum.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
   a. Materials shall be compatible with insulation materials, jackets, and substrates.
   b. Fire- and water-resistant, flexible, elastomeric sealant.
   c. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
   d. Color: White.
   e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. Factory-Applied Jackets

1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
   a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
   b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
   c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
   d. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
   e. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   f. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
   g. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

I. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

J. Field-Applied Fabric-Reinforcing Mesh
1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
2. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.

K. Field-Applied Cloths
1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

L. Field-Applied Jackets
1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
2. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
3. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
   a. Adhesive: As recommended by jacket material manufacturer.
   b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
   c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   d. Factory-fabricated tank heads and tank side panels.
4. Metal Jacket:

a. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
   1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
   2) Finish and thickness are indicated in field-applied jacket schedules.
   3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
   4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
   5) Factory-Fabricated Fitting Covers:
      a) Same material, finish, and thickness as jacket.
      b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      c) Tee covers.
      d) Flange and union covers.
      e) End caps.
      f) Beveled collars.
      g) Valve covers.
      h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
   2) Material, finish, and thickness are indicated in field-applied jacket schedules.
   3) Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
   4) Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper **OR** 2.5-mil- (0.063-mm-) thick Polysurlyn, **as directed**.
   5) Factory-Fabricated Fitting Covers:
      a) Same material, finish, and thickness as jacket.
      b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      c) Tee covers.
      d) Flange and union covers.
      e) End caps.
      f) Beveled collars.
      g) Valve covers.
      h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

5. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
6. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white **OR** stucco-embossed, **as directed**, aluminum-foil facing.
7. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
8. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
9. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

M. Tapes
1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
   a. Width: 3 inches (75 mm).
   b. Thickness: 11.5 mils (0.29 mm).
   c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   d. Elongation: 2 percent.
   e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   a. Width: 3 inches (75 mm).
   b. Thickness: 6.5 mils (0.16 mm).
   c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   d. Elongation: 2 percent.
   e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   a. Width: 2 inches (50 mm).
   b. Thickness: 6 mils (0.15 mm).
   c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   d. Elongation: 500 percent.
   e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
   a. Width: 2 inches (50 mm).
   b. Thickness: 3.7 mils (0.093 mm).
   c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   d. Elongation: 5 percent.
   e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   a. Width: 3 inches (75 mm).
   b. Film Thickness: 4 mils (0.10 mm).
   c. Adhesive Thickness: 1.5 mils (0.04 mm).
   d. Elongation at Break: 145 percent.
   e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.
6. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
   a. Width: 3 inches (75 mm).
   b. Film Thickness: 6 mils (0.15 mm).
   c. Adhesive Thickness: 1.5 mils (0.04 mm).
   d. Elongation at Break: 145 percent.
   e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

N. Securements
1. Bands:
   a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
   b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
   c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
2. Insulation Pins and Hangers:

a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated.
b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   1) Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
d. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   1) Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   2) Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   1) Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   2) Spindle: Copper- or zinc-coated, low carbon steel **OR** Aluminum **OR** Stainless steel, **as directed**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   3) Adhesive-backed base with a peel-off protective cover.
f. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
   1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
g. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

3. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
4. Wire: 0.080-inch (2.0-mm) nickel-copper alloy **OR** 0.062-inch (1.6-mm) soft-annealed, stainless steel **OR** 0.062-inch (1.6-mm) soft-annealed, galvanized steel, **as directed**.

O. Corner Angles
1. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

2. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005; Temper H-14.
3. Stainless-Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**.

1.3 EXECUTION

A. Preparation
1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
OR
Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   b. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

B. General Installation Requirements
1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   a. Install insulation continuously through hangers and around anchor attachments.
   b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
   c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
12. Install insulation with factory-applied jackets as follows:
    a. Draw jacket tight and smooth.
    b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
    c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**, o.c.
        1) For below ambient services, apply vapor-barrier mastic over staples.
    d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
    e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
16. For above ambient services, do not install insulation to the following:
    a. Vibration-control devices.
    b. Testing agency labels and stamps.
    c. Nameplates and data plates.
    d. Manholes.
    e. Handholes.
    f. Cleanouts.

C. Penetrations
1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
    a. Seal penetrations with flashing sealant.
    b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
    d. Seal jacket to roof flashing with flashing sealant.
2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
    a. Seal penetrations with flashing sealant.
    b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
    d. Seal jacket to wall flashing with flashing sealant.

4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
   a. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems" for firestopping and fire-resistive joint sealers.
6. Insulation Installation at Floor Penetrations:
   a. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
   b. Pipe: Install insulation continuously through floor penetrations.
   c. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".

D. Equipment, Tank, And Vessel Insulation Installation
1. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
   b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
   c. Protect exposed corners with secured corner angles.
   d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      1) Do not weld anchor pins to ASME-labeled pressure vessels.
      2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      3) On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
      4) Do not overcompress insulation during installation.
      5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
      6) Impale insulation over anchor pins and attach speed washers.
      7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
   e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
   f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
   g. Stagger joints between insulation layers at least 3 inches (75 mm).
   h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
   a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
   b. Seal longitudinal seams and end joints.
3. Insulation Installation on Pumps:
   a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   b. Fabricate boxes from galvanized steel **OR** aluminum **OR** stainless steel, **as directed**, at least 0.040 inch (1.0 mm) **OR** 0.050 inch (1.3 mm) **OR** 0.060 inch (1.6 mm), **as directed**, thick.
   c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

E. General Pipe Insulation Installation
1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
   a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
   b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
   c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
   d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
   e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
   f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
   g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
   h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and

unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.

i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

4. Install removable insulation covers at locations indicated. Installation shall conform to the following:

a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

b. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.

d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

F. Calcium Silicate Insulation Installation

1. Insulation Installation on Boiler Breechings and Ducts:

a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation material.

b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

c. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

2. Insulation Installation on Straight Pipes and Tubes:

a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.

b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

3. Insulation Installation on Pipe Flanges:

a. Install preformed pipe insulation to outer diameter of pipe flange.

b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
d. Finish flange insulation same as pipe insulation.

4. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
   c. Finish fittings insulation same as pipe insulation.
5. Insulation Installation on Valves and Pipe Specialties:
   a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   b. Install insulation to flanges as specified for flange insulation application.
   c. Finish valve and specialty insulation same as pipe insulation.

G. Cellular-Glass Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
   b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of cellular-glass insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

H. Flexible Elastomeric Insulation Installation
1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges:
   a. Install pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install mitered sections of pipe insulation.
   b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed valve covers manufactured of same material as pipe insulation when available.
   b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.
   d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

I. Mineral-Fiber Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
   b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
   c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
   d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
   d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
   c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   d. Install insulation to flanges as specified for flange insulation application.
5. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of duct and plenum surfaces.
b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
   1) On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
   2) On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   4) Do not overcompress insulation during installation.
   5) Impale insulation over pins and attach speed washers.
   6) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   2) Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).
e. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
f. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
g. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

6. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of duct and plenum surfaces.
   b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
   c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
      1) On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
      2) On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
4) Do not overcompress insulation during installation.
5) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
2) Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than 3 inches (75 mm).

e. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

f. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

J. Phenolic Insulation Installation
1. General Installation Requirements:
a. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
b. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
2. Insulation Installation on Straight Pipes and Tubes:
a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at 6 inches (150 mm) o.c.
d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Insulation Installation on Pipe Flanges:
a. Install preformed pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Insulation Installation on Pipe Fittings and Elbows:
a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
5. Insulation Installation on Valves and Pipe Specialties:

a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

K. Polyisocyanurate Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
a. Install preformed pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
3. Insulation Installation on Fittings and Elbows:
a. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
a. Install preformed sections of polyisocyanurate insulation to valve body.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

L. Polyolefin Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges:
a. Install pipe insulation to outer diameter of pipe flange.
b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
3. Insulation Installation on Pipe Fittings and Elbows:
a. Install mitered sections of polyolefin pipe insulation.
b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
4. Insulation Installation on Valves and Pipe Specialties:
a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
c. Install insulation to flanges as specified for flange insulation application.

d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

M. Polystyrene Insulation Installation
1. Insulation Installation on Straight Pipes and Tubes:
   a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
   b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
   c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
   a. Install preformed pipe insulation to outer diameter of pipe flange.
   b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
   c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
   a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
   a. Install preformed section of polystyrene insulation to valve body.
   b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
   c. Install insulation to flanges as specified for flange insulation application.

N. Field-Applied Jacket Installation
1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
   a. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
   b. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
   c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
   a. Draw jacket material smooth and tight.
   b. Install lap or joint strips with same material as jacket.
   c. Secure jacket to insulation with manufacturer's recommended adhesive.
   d. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
   e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
3. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
   a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
4. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.
5. Where PVDC jackets are indicated, install as follows:

a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
b. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

O. Fire-Rated Insulation System Installation
1. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
2. Insulate duct access panels and doors to achieve same fire rating as duct.
3. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Through-penetration Firestop Systems".

P. Finishes
1. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
1) Finish Coat Material: Interior, flat, latex-emulsion size.
2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
4. Do not field paint aluminum or stainless-steel jackets.

Q. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
a. Inspect ductwork, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
b. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
c. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations

of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

R. Boiler Breeching Insulation Schedule

1. Round, exposed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
2. Round, concealed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
3. Rectangular, exposed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
4. Rectangular, concealed breeching and connector insulation shall be one of the following:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. High-Temperature Mineral-Fiber Blanket: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) nominal density.
   c. High-Temperature Mineral-Fiber Board: 3 inches (75 mm) thick and 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.

S. Duct Insulation Schedule, General

1. Plenums and Ducts Requiring Insulation:
   a. Indoor, concealed supply and outdoor air.
   b. Indoor, exposed supply and outdoor air.
   c. Indoor, concealed return located in nonconditioned space.
   d. Indoor, exposed return located in nonconditioned space.
   e. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
   f. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
   g. Indoor, concealed oven and warewash exhaust.
   h. Indoor, exposed oven and warewash exhaust.
   i. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
   j. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
   k. Outdoor, concealed supply and return.
   l. Outdoor, exposed supply and return.
2. Items Not Insulated:
   a. Fibrous-glass ducts.
   b. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   c. Factory-insulated flexible ducts.
   d. Factory-insulated plenums and casings.
   e. Flexible connectors.
   f. Vibration-control devices.
   g. Factory-insulated access panels and doors.

T. Indoor Duct And Plenum Insulation Schedule

1. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm) thick.
2. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm) thick.
3. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm) thick.
4. Concealed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm) thick.
5. Concealed, rectangular, supply-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm) thick.

6. Concealed, rectangular, return-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm), **as directed**, thick.
7. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm), **as directed**, thick.
8. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
   a. Flexible Elastomeric: 1 inch (25 mm) thick.
   b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   e. Polyolefin: 1 inch (25 mm) thick.
9. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket **OR** board, **as directed**; thickness as required to achieve 2-hour fire rating.
10. Concealed, supply-air plenum insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
    e. Polyolefin: 1 inch (25 mm) thick.
11. Concealed, return-air plenum insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.

d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
e. Polyolefin: 1 inch (25 mm) thick.

12. Concealed, outdoor-air plenum insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
13. Concealed, exhaust-air plenum insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
14. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
    e. Polyolefin: 1 inch (25 mm) thick.
15. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
    e. Polyolefin: 1 inch (25 mm) thick.
16. Exposed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
    e. Polyolefin: 1 inch (25 mm) thick.
17. Exposed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.

b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
e. Polyolefin: 1 inch (25 mm) thick.

18. Exposed, rectangular, supply-air duct insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch (25 mm) thick.
b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96 kg/cu. m), **as directed**, nominal density.
d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
e. Polyolefin: 1 inch (25 mm) thick.

19. Exposed, rectangular, return-air duct insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch (25 mm) thick.
b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
e. Polyolefin: 1 inch (25 mm) thick.

20. Exposed, rectangular, outdoor-air duct insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch (25 mm) thick.
b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
e. Polyolefin: 1 inch (25 mm) thick.

21. Exposed, rectangular, exhaust-air duct insulation shall be one of the following:
a. Flexible Elastomeric: 1 inch (25 mm) thick.
b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
e. Polyolefin: 1 inch (25 mm) thick.

22. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket **OR** board, **as directed**; thickness as required to achieve 2-hour fire rating.

23. Exposed, supply-air plenum insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
    e. Polyolefin: 1 inch (25 mm) thick.
24. Exposed, return-air plenum insulation shall be one of the following:
    a. Flexible Elastomeric: 1 inch (25 mm) thick.
    b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
    e. Polyolefin: 1 inch (25 mm) thick.
25. Exposed, outdoor-air plenum insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
26. Exposed, exhaust-air plenum insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.

U. Aboveground, Outdoor Duct And Plenum Insulation Schedule
1. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
2. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
3. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.

b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.

4. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
   a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed,** and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
5. Concealed, rectangular, supply-air duct insulation shall be one of the following:
   a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
6. Concealed, rectangular, return-air duct insulation shall be one of the following:
   a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m, **as directed**, nominal density.
   b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
7. Concealed, supply-air plenum insulation shall be one of the following:
   a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
8. Concealed, return-air plenum insulation shall be one of the following:
   a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
9. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
   a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
   b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
10. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:

a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.

11. Exposed, rectangular, supply-air duct insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
12. Exposed, rectangular, return-air duct insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
13. Exposed, supply-air plenum insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
14. Exposed, return-air plenum insulation shall be one of the following:
    a. Mineral-Fiber Blanket: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, and 0.75-lb/cu. ft. (12-kg/cu. m) **OR** 1.5-lb/cu. ft. (24-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m), **as directed**, nominal density.
    b. Mineral-Fiber Board: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.

V. Equipment Insulation Schedule
1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
3. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
4. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:

a. Cellular Glass: 2 inches (50 mm) thick.
b. Flexible Elastomeric: 1 inch (25 mm) thick.
c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
e. Phenolic: 1 inch (25 mm) thick.
f. Polyisocyanurate: 1 inch (25 mm) thick.
g. Polyolefin: 1 inch (25 mm) thick.

5. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:
   a. Calcium Silicate: 3 inches (75 mm) thick.
   b. Cellular Glass: 3 inches (75 mm) thick.
   c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
6. Steam-to-hot-water converter insulation shall be one of the following:
   a. Calcium Silicate: 3 inches (75 mm) thick.
   b. Cellular Glass: 3 inches (75 mm) thick.
   c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
7. Hot-water-to-steam converter insulation shall be one of the following:
   a. Calcium Silicate: 3 inches (75 mm) thick.
   b. Cellular Glass: 3 inches (75 mm) thick.
   c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
8. Chilled-water pump insulation shall be one of the following:
   a. Cellular Glass: 3 inches (75 mm) thick.
   b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 2 inches (50 mm) thick.
   d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
9. Condenser-water pump insulation shall be one of the following:
   a. Cellular Glass: 2 inches (50 mm) thick.
   b. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
   c. Phenolic: 1 inch (25 mm) thick.
   d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.
10. Dual-service heating and cooling pump insulation shall be one of the following:
    a. Cellular Glass: 3 inches (75 mm) thick.
    b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 2 inches (50 mm) thick.
    d. Polyisocyanurate: 1 inch (25 mm) thick.
11. Heating-hot-water pump insulation shall be one of the following:
    a. Calcium Silicate: 3 inches (75 mm) thick.
    b. Cellular Glass: 3 inches (75 mm) thick.
    c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
12. Heat-recovery pump insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Phenolic: 1 inch (25 mm) thick.
    d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.

13. Steam condensate pump and boiler feedwater pump insulation shall be one of the following:
    a. Calcium Silicate: 3 inches (75 mm) thick.
    b. Cellular Glass: 3 inches (75 mm) thick.
    c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
14. Chilled-water expansion/compression tank insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches (38 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
15. Condenser-water expansion/compression tank insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches (38 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
16. Dual-service heating and cooling expansion/compression tank insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches (38 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
17. Heating-hot-water expansion/compression tank insulation shall be one of the following:
    a. Calcium Silicate: 2 inches (50 mm) thick.
    b. Cellular Glass: 1-1/2 inches (38 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
18. Heat-recovery expansion/compression tank insulation shall be one of the following:
    a. Cellular Glass: 1-1/2 inches (38 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
19. Chilled-water air-separator insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.

f. Polyisocyanurate: 1 inch (25 mm) thick.
g. Polyolefin: 1 inch (25 mm) thick.

20. Condenser-water air-separator insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
21. Dual-service heating and cooling air-separator insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
22. Heating-hot-water air-separator insulation shall be one of the following:
    a. Calcium Silicate: 3 inches (75 mm) thick.
    b. Cellular Glass: 3 inches (75 mm) thick.
    c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
23. Heat-recovery air-separator insulation shall be one of the following:
    a. Cellular Glass: 2 inches (50 mm) thick.
    b. Flexible Elastomeric: 1 inch (25 mm) thick.
    c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
    e. Phenolic: 1 inch (25 mm) thick.
    f. Polyisocyanurate: 1 inch (25 mm) thick.
    g. Polyolefin: 1 inch (25 mm) thick.
24. Thermal storage tank (brine, water, ice) insulation shall be one of the following:
    a. Cellular Glass: 4 inches (100 mm) thick.
    b. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Pipe and Tank: 3 inches (75 mm) thick.
    d. Phenolic: 3 inches (75 mm) thick.
    e. Polyisocyanurate (Outdoor Application Only): 3 inches (75 mm) thick.
    f. Polystyrene (Outdoor Application Only): 3 inches (75 mm) thick.
25. Deaerator insulation shall be one of the following:
    a. Calcium Silicate: 3 inches (75 mm) thick.
    b. Cellular Glass: 3 inches (75 mm) thick.
    c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
26. Steam condensate tank and receiver insulation shall be one of the following:
    a. Calcium Silicate: 3 inches (75 mm) thick.
    b. Cellular Glass: 3 inches (75 mm) thick.
    c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

27. Steam flash-tank, flash-separator, and blow-off-tank insulation shall be one of the following:
    a. Calcium Silicate: 3 inches (75 mm) thick.
    b. Cellular Glass: 3 inches (75 mm) thick.
    c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
28. Piping system filter-housing insulation shall be one of the following:
    a. Cellular Glass: 3 inches (75 mm) thick.
    b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
29. Outdoor, aboveground, heated, fuel-oil storage tank insulation shall be one of the following:
    a. Cellular Glass: 3 inches (75 mm) thick.
    b. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) **OR** 3-lb/cu. ft. (48-kg/cu. m) **OR** 6-lb/cu. ft. (96-kg/cu. m), **as directed**, nominal density.
    c. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
    d. Polyisocyanurate: 1-1/2 inches (38 mm) thick.

W. Piping Insulation Schedule, General
1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
    a. Drainage piping located in crawl spaces.
    b. Underground piping.
    c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

X. Indoor Piping Insulation Schedule
1. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
        4) Phenolic: 1 inch (25 mm) thick.
        5) Polyisocyanurate: 1 inch (25 mm) thick.
        6) Polyolefin: 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, thick.
2. Chilled Water and Brine, 40 Deg F (5 Deg C) and below:
    a. NPS 3 (DN 80) and Smaller: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
        2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
        3) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
        4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
    b. NPS 4 (DN 100) to NPS 12 (DN 300): Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
        2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
        3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
        4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
    c. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
        1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.

2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.

3. Chilled Water and Brine, above 40 Deg F (5 Deg C):
   a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      2) Flexible Elastomeric: 1 inch (25 mm) thick.
      3) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      4) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      5) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
      6) Polyolefin: 1 inch (25 mm) thick.
   b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
      1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      2) Mineral-Fiber Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
4. Condenser-Water Supply and Return:
   a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      2) Flexible Elastomeric: 1 inch (25 mm) thick.
      3) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      4) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
      5) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
      6) Polyolefin: 1 inch (25 mm) thick.
   b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
      1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      2) Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.
5. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and below:
   a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      2) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      3) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
   b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
      1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      2) Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.

6. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):
   a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
      1) Calcium Silicate: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      2) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
      1) Calcium Silicate: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
      2) Cellular Glass: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
7. Steam and Steam Condensate, 350 Deg F (177 Deg C) and below:
   a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
      1) Calcium Silicate: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      2) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
      1) Calcium Silicate: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
      2) Cellular Glass: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
8. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
   a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
      1) Calcium Silicate: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      2) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
   b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
      1) Calcium Silicate: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
      2) Cellular Glass: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
      3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) **OR** 4 inches (100 mm), **as directed**, thick.
9. Refrigerant Suction and Hot-Gas Piping:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) thick.
      2) Flexible Elastomeric: 1 inch (25 mm) thick.
      3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
      4) Phenolic: 1 inch (25 mm) thick.
      5) Polyisocyanurate: 1 inch (25 mm) thick.
      6) Polyolefin: 1 inch (25 mm) thick.
10. Refrigerant Suction and Hot-Gas Flexible Tubing:
   a. All Pipe Sizes: Insulation shall be one of the following:
      1) Flexible Elastomeric: 1 inch (25 mm) thick.
      2) Polyolefin: 1 inch (25 mm) thick.
11. Dual-Service Heating and Cooling, 40 to 200 Deg F (5 to 93 Deg C):
   a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
      1) Cellular Glass: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      2) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**, thick.
      3) Phenolic: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
      4) Polyisocyanurate: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**, thick.
   b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
      1) Cellular Glass: 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.

2) Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
3) Phenolic: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**, thick.
4) Polyisocyanurate: 1-1/2 inches (38 mm) thick.

12. Heat-Recovery Piping:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 1-1/2 inches (38 mm) thick.
        2) Flexible Elastomeric: 1 inch (25 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
        4) Phenolic: 1 inch (25 mm) thick.
        5) Polyisocyanurate: 1 inch (25 mm) thick.
        6) Polyolefin: 1 inch (25 mm) thick.
13. Hot Service Drains:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
        2) Cellular Glass: 1-1/2 inches (38 mm) thick.
        3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.
14. Hot Service Vents:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
        2) Cellular Glass: 1-1/2 inches (38 mm) thick.
        3) Mineral-Fiber, Preformed Pipe, Type I or II: 1 inch (25 mm) thick.

Y. Outdoor, Aboveground Piping Insulation Schedule
1. Chilled Water and Brine:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 3 inches (75 mm) thick.
        2) Flexible Elastomeric: 3 inches (75 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 3 inches (75 mm) thick.
        4) Phenolic: 2 inches (50 mm) thick.
        5) Polyisocyanurate: 2 inches (50 mm) thick.
        6) Polyolefin: 3 inches (75 mm) thick.
        7) Polystyrene: 2 inches (50 mm) thick.
2. Condenser-Water Supply and Return:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 2 inches (50 mm) thick.
        2) Flexible Elastomeric: 2 inches (50 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
        4) Phenolic: 2 inches (50 mm) thick.
        5) Polyisocyanurate: 2 inches (50 mm) thick.
        6) Polyolefin: 2 inches (50 mm) thick.
        7) Polystyrene: 2 inches (50 mm) thick.
3. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and below:
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Cellular Glass: 3 inches (75 mm) thick.
        2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
        3) Phenolic: 2 inches (50 mm) thick.
        4) Polyisocyanurate: 2 inches (50 mm) thick.
4. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):
    a. All Pipe Sizes: Insulation shall be one of the following:
        1) Calcium Silicate: 3 inches (75 mm) thick.
        2) Cellular Glass: 3 inches (75 mm) thick.
        3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 2 inches (50 mm) thick.
5. Steam and Steam Condensate, 350 Deg F (177 Deg C) and below:

a. All Pipe Sizes: Insulation shall be one of the following:
1) Calcium Silicate: 4 inches (100 mm) thick.
2) Cellular Glass: 4 inches (100 mm) thick.
3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 3 inches (75 mm) thick.

6. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
a. All Pipe Sizes: Insulation shall be one of the following:
1) Calcium Silicate: 5 inches (125 mm) thick.
2) Cellular Glass: 5 inches (125 mm) thick.
3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 4 inches (100 mm) thick.

7. Refrigerant Suction and Hot-Gas Piping:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Cellular Glass: 2 inches (50 mm) thick.
2) Flexible Elastomeric: 2 inches (50 mm) thick.
3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
4) Phenolic: 2 inches (50 mm) thick.
5) Polyisocyanurate: 2 inches (50 mm) thick.
6) Polyolefin: 2 inches (50 mm) thick.
7) Polystyrene: 2 inches (50 mm) thick.

8. Refrigerant Suction and Hot-Gas Flexible Tubing:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Flexible Elastomeric: 2 inches (50 mm) thick.
2) Polyolefin: 2 inches (50 mm) thick.

9. Heat-Recovery Piping:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Cellular Glass: 2 inches (50 mm) thick.
2) Flexible Elastomeric: 2 inches (50 mm) thick.
3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
4) Phenolic: 2 inches (50 mm) thick.
5) Polyisocyanurate: 2 inches (50 mm) thick.
6) Polyolefin: 2 inches (50 mm) thick.
7) Polystyrene: 2 inches (50 mm) thick.

10. Dual-Service Heating and Cooling:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Cellular Glass: 3 inches (75 mm) thick.
2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
3) Phenolic: 2 inches (50 mm) thick.
4) Polyisocyanurate: 2 inches (50 mm) thick.

11. Hot Service Drains:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
2) Cellular Glass: 1-1/2 inches (38 mm) thick.
3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.

12. Hot Service Vents:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
2) Cellular Glass: 1-1/2 inches (38 mm) thick.
3) Mineral-Fiber, Preformed Pipe Insulation, Type II: 1 inch (25 mm) thick.

13. Fuel Oil Piping, Heated:
a. All Pipe Sizes: Insulation shall be one of the following:
1) Cellular Glass: 2 inches (50 mm) thick.
2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.

Z. Outdoor, Underground Piping Insulation Schedule
1. Loose-fill insulation, for belowground piping, is specified in Division 02.
2. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.
3. Condenser-Water Supply and Return, All Sizes: Cellular glass, 2 inches (50 mm) thick.

4. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F (93 Deg C) and below: Cellular glass, 3 inches (75 mm) thick.
5. Heating-Hot-Water Supply and Return, All Sizes, above 200 Deg F (93 Deg C):
   a. Calcium Silicate: 3 inches (75 mm) thick.
   b. Cellular Glass: 3 inches (75 mm) thick.
6. Steam and Steam Condensate, All Sizes, 350 Deg F (177 Deg C) and below:
   a. Calcium Silicate: 4 inches (100 mm) thick.
   b. Cellular Glass: 4 inches (100 mm) thick.
7. Steam and Steam Condensate, All Sizes, above 350 Deg F (177 Deg C):
   a. Calcium Silicate: 5 inches (125 mm) thick.
   b. Cellular Glass: 5 inches (125 mm) thick.
8. Dual-Service Heating and Cooling, All Sizes, 40 to 200 Deg F (4 to 93 Deg C): Cellular glass, 3 inches (75 mm) thick.
9. Fuel Oil Piping, All Sizes, Heated: Cellular glass, 2 inches (50 mm) thick.

AA. Indoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Ducts and Plenums, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Ducts and Plenums, Exposed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Equipment, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.

e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

6. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
   a. None.
   b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
8. Piping, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
9. Piping, Exposed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

BB. Outdoor, Field-Applied Jacket Schedule

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Ducts and Plenums, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
   a. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   b. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
   a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Equipment, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed,** thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
   a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm)

OR 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.

b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed** with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

8. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
   a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
9. Piping, Concealed:
   a. None.
   b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
   c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
   e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
10. Piping, Exposed:
   a. PVC: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm) **OR** 40 mils (1.0 mm), **as directed**, thick.
   b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
   c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

CC. Underground, Field-Installed Insulation Jacket
1. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 15190

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SECTION 15230 - WATER DISTRIBUTION PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for domestic water pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. In-line, sealless centrifugal pumps.
b. Horizontally mounted, in-line, separately coupled centrifugal pumps.
c. Horizontally mounted, in-line, close-coupled centrifugal pumps.
d. Vertically mounted, in-line, close-coupled centrifugal pumps.

C. Definitions
1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Submittals
1. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

F. Delivery, Storage, And Handling
1. Retain shipping flange protective covers and protective coatings during storage.
2. Protect bearings and couplings against damage.
3. Comply with pump manufacturer's written rigging instructions for handling.

G. Coordination
1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.2 PRODUCTS

A. In-Line, Sealless Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
2. Pump Construction:
a. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
b. Casing: Bronze, with threaded or companion-flange connections.
c. Impeller: Plastic.
d. Motor: Single speed, unless otherwise indicated.

B. Horizontally Mounted, In-Line, Separately Coupled Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, single-stage, separately coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shafts mounted horizontal.
2. Pump Construction:
a. Casing: Radially split with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
b. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
d. Coupling: Flexible.
e. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
f. Bearings: Oil-lubricated; bronze-journal or ball type.
g. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
3. Motor: Single speed, with grease-lubricated ball bearings; and resiliently **OR** rigidly, **as directed**, mounted to pump casing.

C. Horizontally Mounted, In-Line, Close-Coupled Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.
2. Pump Construction:
a. Casing: Radially split with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
b. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
c. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
e. Bearings: Oil-lubricated; bronze-journal or ball type.
f. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
3. Motor: Single speed, with grease-lubricated ball bearings; and resiliently or rigidly mounted to pump casing.

D. Vertically Mounted, In-Line, Close-Coupled Centrifugal Pumps
1. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.
2. Pump Construction:
a. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections. Include pump manufacturer's base attachment for mounting pump on concrete base, **as directed**.
b. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.
c. Shaft and Shaft Sleeve: Stainless-steel or steel **OR** Stainless-steel, **as directed**, shaft, with copper-alloy shaft sleeve.
d. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
e. Bearings: Oil-lubricated; bronze-journal or ball type.
f. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.
3. Motor: Single speed, with grease-lubricated ball bearings; and rigidly mounted to pump casing.

E. Motors

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Plumbing Equipment".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.

F. Controls
1. Pressure Switches: Electric, adjustable for control of water-supply pump.
   a. Type: Water-immersion pressure sensor, for installation in piping.
   b. Enclosure: NEMA 250, Type 4X.
   c. Operation of Pump: On or off.
   d. Transformer: Provide if required.
   e. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
   f. Settings: Start pump at <**Insert pressure**> and stop pump at <**Insert pressure**>.
2. Thermostats: Electric; adjustable for control of hot-water circulation pump.
   a. Type: Water-immersion temperature sensor, for installation in piping.
   b. Range: 50 to 125 deg F (10 to 52 deg C) **OR** 65 to 200 deg F (18 to 93 deg C) **OR** 100 to 240 deg F (38 to 116 deg C), **as directed**.
   c. Enclosure: NEMA 250, Type 4X.
   d. Operation of Pump: On or off.
   e. Transformer: Provide if required.
   f. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
   g. Settings: Start pump at 105 deg F (41 deg C) **OR** 110 deg F (43 deg C) **OR** 115 deg F (46 deg C), **as directed**, and stop pump at 120 deg F (49 deg C) **OR** 125 deg F (52 deg C), **as directed**.
3. Timers: Electric, for control of hot-water circulation pump.
   a. Type: Programmable, seven-day clock with manual override on-off switch.
   b. Enclosure: NEMA 250, Type 1.suitable for wall mounting.
   c. Operation of Pump: On or off.
   d. Transformer: Provide if required.
   e. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
   f. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.
4. Time-Delay Relays: Electric, for control of hot-water circulation pump between water heater and connected hot-water storage tank.
   a. Type: Adjustable time-delay relay.
   b. Range: Up to five minutes.
   c. Setting: Five minutes.
   d. Enclosure: NEMA 250, Type 4X.
   e. Operation of Pump: On or off.
   f. Transformer: Provide if required.
   g. Power Requirement: 24 V, ac **OR** 120 V, ac, **as directed**.
   h. Programmable Sequence of Operation: Limit pump operation to periods of burner operation plus maximum five minutes after the burner stops.

1.3 EXECUTION

A. Examination
1. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

B. Pump Installation
1. Comply with HI 1.4.
2. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.

3. Install horizontally mounted, in-line, separately coupled and close-coupled centrifugal pumps with shaft(s) horizontal.
4. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
5. Pump Mounting: Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install continuous-thread hanger rods and spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support pump weight.
   a. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment". Fabricate brackets or supports as required.
   b. Comply with requirements for hangers and supports specified in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment".
7. Install pressure switches in water supply piping.
8. Install thermostats in hot-water return piping.
9. Install timers on wall in engineer's office, **as directed**.
10. Install time-delay relays in piping between water heaters and hot-water storage tanks.

C. Connections
1. Comply with requirements for piping specified in Division 15 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to pumps to allow service and maintenance.
3. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
   a. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
      1) Horizontally mounted, in-line, separately coupled centrifugal pumps.
      2) Horizontally mounted, in-line, close-coupled centrifugal pumps.
      3) Vertically mounted, in-line, close-coupled centrifugal pumps.
      4) Comply with requirements for flexible connectors specified in Division 15 Section "Domestic Water Piping".
   b. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Division 15 Section "General-duty Valves For Plumbing Piping" and comply with requirements for strainers specified in Division 15 Section "Domestic Water Piping Specialties".
   c. Install pressure gage and snubber, **as directed**, at suction of each pump and pressure gage and snubber, **as directed**, at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Division 15 Section "Meters And Gages For Plumbing Piping".
4. Comply with Division 15 for electrical connections, and wiring methods.
5. Connect pressure switches, thermostats, time-delay relays, and timers to pumps that they control.
6. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

D. Identification
   1. Comply with requirements for identification specified in Division 15 Section "Identification For Plumbing Piping And Equipment" for identification of pumps.

E. Startup Service
   1. Engage a factory-authorized service representative to perform **OR** Perform, **as directed**, startup service.
      a. Complete installation and startup checks according to manufacturer's written instructions.
      b. Check piping connections for tightness.
      c. Clean strainers on suction piping.
      d. Set pressure switches, thermostats, timers, and time-delay relays for automatic starting and stopping operation of pumps.
      e. Perform the following startup checks for each pump before starting:
         1) Verify bearing lubrication.
         2) Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
         3) Verify that pump is rotating in the correct direction.
      f. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
      g. Start motor.
      h. Open discharge valve slowly.
      i. Adjust temperature settings on thermostats.
      j. Adjust timer settings.

F. Adjusting
   1. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
   2. Adjust initial temperature set points.
   3. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 15230

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SECTION 15230a - PACKAGED BOOSTER PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for packaged booster pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Simplex, constant-speed booster pumps.
b. Multiplex, constant-speed booster pumps.
c. Simplex, variable-speed booster pumps.
d. Multiplex, variable-speed booster pumps.

C. Definitions
1. VFC: Variable-frequency controller(s).

D. Performance Requirements
1. Seismic Performance: Booster pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the booster pump will remain in place without separation of any parts from the booster pump when subjected to the seismic forces specified and the booster pump will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles **OR** Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories, **as directed**.
2. Shop Drawings: For booster pumps. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For booster pumps, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Operation and Maintenance Data: For booster pumps to include in emergency, operation, and maintenance manuals.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Comply with ASME B31.9 for piping.
3. UL Compliance for Packaged Pumping Systems:
a. UL 508, "Industrial Control Equipment."

b. UL 508A, "Industrial Control Panels."
c. UL 778, "Motor-Operated Water Pumps."
d. UL 1995, "Heating and Cooling Equipment."

4. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

G. Delivery, Storage, And Handling
1. Retain protective coatings and flange's protective covers during storage.

H. Coordination
1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.2 PRODUCTS

A. Simplex, Constant-Speed Booster Pumps
1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pump, piping, valves, specialties, and controls, and mounted on base.
2. Pump:
a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **s directed**; statically and dynamically balanced and keyed to shaft.
d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
e. Seal: Mechanical.
f. Orientation: Mounted horizontally or vertically.
3. Motor: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings, and directly mounted to pump casing. Select motor that will not overload through full range of pump performance curve.
4. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
5. Valves:
a. Shutoff Valves NPS 2 (DN 50) and smaller: Gate valve or two-piece, full-port ball valve, in pump suction and discharge piping.
b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in pump suction and discharge piping.
c. Check Valve NPS 2 (DN 50) and smaller: Silent or swing type in pump discharge piping.
d. Check Valve NPS 2-1/2 (DN 65) and Larger: Silent type in pump discharge piping.
e. Control Valve: Adjustable, automatic, pilot-operated or direct-acting, pressure-reducing type in pump discharge piping.
f. Control Valve: Combination adjustable, automatic, pilot-operated or direct-acting pressure-reducing-and-check type in pump discharge piping.
g. Thermal-Relief Valve: Temperature-and-pressure relief type in pump discharge piping.
6. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
7. Hydropneumatic Tank: Precharged, ASME-construction, **as directed**, diaphragm or bladder tank made of materials complying with NSF 61.
8. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for single-pump, constant-speed operation, with load control and protection functions.
a. Control Logic: Electromechanical system with switches, relays **OR** Solid-state system with transducers, programmable microprocessor, **as directed**, and other devices in the controller.

b. Motor Controller: NEMA ICS 2, general-purpose, Class A, full-voltage, combination-magnetic type with undervoltage release feature, motor-circuit-protector-type disconnect, and short-circuit protective device.
   1) Control Voltage: 24 **OR** 120, **as directed**,-V ac, with integral control-power transformer.
c. Motor Controller: NEMA ICS 2, solid-state, reduced-voltage type.
   1) Control Voltage: 24 **OR** 120, **as directed**,-V ac, with integral control-power transformer.
d. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.
e. Motor Overload Protection: Overload relay in each phase.
f. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
g. Pump Operation: Current- or pressure- sensing method.
   1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
h. Instrumentation: Suction and discharge pressure gages.
i. Light: Running light for pump.
j. Thermal-bleed cutoff.
k. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.
l. High-suction-pressure cutout.
m. Low-discharge-pressure cutout.
n. High-discharge-pressure cutout.
o. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 15 Section "Hvac Instrumentation And Controls". Include the following:
   1) On-off status of pump.
   2) Alarm status.

9. Base: Structural steel.

B. Multiplex, Constant-Speed Booster Pumps
1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
2. Pumps:
   a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
   b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
   c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
   d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
   e. Seal: Mechanical.
   f. Orientation: Mounted horizontally or vertically.

   OR

   Pumps:
   a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, frame-mounted, separately coupled, single-stage, overhung-impeller, centrifugal pump. Include back-pullout design, **as directed**.
   b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
   c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
   d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve and deflector.
   e. Seal: Mechanical.
   f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
   g. Coupling: Flexible, with metal guard.

   OR

   Pumps:

a. Type: In line, single stage as defined in HI 1.1-1.2 and HI 1.3 for in-line, single-stage, close-coupled, overhung-impeller, centrifugal pump.
b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve.
e. Seal: Mechanical.
f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.

OR

Pumps:

a. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
b. Casing: Cast-iron or steel base and stainless-steel chamber.
c. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
d. Shaft: Stainless steel.
e. Seal: Mechanical.
f. Bearing: Water-lubricated sleeve type.

OR

Pumps:

a. Type: Vertical, can, as defined in HI 2.1-2.2 and HI 2.3 for in-line, barrel or can, lineshaft, vertical pump.
b. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
c. Bowls: Epoxy-coated cast iron **OR** Cast iron, **as directed**.
d. Shaft: Stainless steel.
e. Seals: Mechanical and stuffing-box types.
f. Bearings: Water-lubricated bushing type.

3. Motors: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.
4. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
5. Valves:
   a. Shutoff Valves NPS 2 (DN 50) and smaller: Gate valve or two-piece, full-port ball valve, in each pump's suction and discharge piping.
   b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers, **as directed**.
   c. Check Valves NPS 2 (DN 50) and smaller: Silent or swing type in each pump's discharge piping.
   d. Check Valves NPS 2-1/2 (DN 65) and Larger: Silent type in each pump's discharge piping.
   e. Control Valves: Adjustable, automatic, pilot-operated or direct-acting, pressure-reducing type in each pump's discharge piping.
   f. Control Valves: Combination adjustable, automatic, pilot-operated or direct-acting pressure-reducing-and-check type in each pump's discharge piping.
   g. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
6. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
7. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, constant-speed operation, with load control and protection functions.
   a. Control Logic: Electromechanical system with switches, relays **OR** Solid-state system with transducers, programmable microprocessor, **as directed**, and other devices in the controller.
   b. Motor Controller: NEMA ICS 2, general-purpose, Class A, full-voltage, combination-magnetic type with undervoltage release feature, motor-circuit-protector-type disconnect, and short-circuit protective device.

1) Control Voltage: 24 **OR** 120, **as directed**,-V ac, with integral control-power transformer.

c. Motor Controller: NEMA ICS 2, solid-state, reduced-voltage type.

1) Control Voltage: 24 **OR** 120, **as directed**,-V ac, with integral control-power transformer.

d. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.

e. Motor Overload Protection: Overload relay in each phase.

f. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.

1) Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.

2) Triplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.

g. Pump Operation and Sequencing: Current- or pressure- sensing method.

1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.

h. Instrumentation: Suction and discharge pressure gages.

i. Lights: Running light for each pump.

j. Alarm Signal Device: Sounds alarm when backup pumps are operating.

1) Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic **OR** manual, **as directed**, reset.

k. Thermal-bleed cutoff.

l. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.

m. High-suction-pressure cutout.

n. Low-discharge-pressure cutout.

o. High-discharge-pressure cutout.

p. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 15 Section "Hvac Instrumentation And Controls". Include the following:

1) On-off status of each pump.

2) Alarm status.

8. Base: Structural steel.

C. Simplex, Variable-Speed Booster Pumps

1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pump, piping, valves, specialties, and controls, and mounted on base.

2. Pump:

a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.

b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.

c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.

d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.

e. Seal: Mechanical.

f. Orientation: Mounted horizontally or vertically.

3. Motor: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings, and directly mounted to pump casing. Select motor that will not overload through full range of pump performance curve.

4. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.

5. Valves:

a. Shutoff Valves NPS 2 (DN 50) and Smaller: Gate valve or two-piece, full-port ball valve, in pump suction and discharge piping.

b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in pump suction and discharge piping.

c. Check Valve NPS 2 (DN 50) and Smaller: Silent or swing type in pump discharge piping.
d. Check Valve NPS 2-1/2 (DN 65) and Larger: Silent type in pump discharge piping.
e. Thermal-Relief Valve: Temperature-and-pressure relief type in pump discharge piping.

6. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
7. Hydropneumatic Tank: Precharged, ASME-construction, **as directed**, diaphragm or bladder tank made of materials complying with NSF 61.
8. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for single-pump, variable-speed operation, with load control and protection functions.
   a. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in the controller.
   b. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.
      1) Control Voltage: 24 **OR** 120, **as directed**,-V ac, with integral control-power transformer.
   c. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.
   d. Motor Overload Protection: Overload relay in each phase.
   e. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
   f. Pump Operation: Pressure-sensing method.
      1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.
   g. VFC: Voltage-source, pulse-width, modulating-frequency converter; installed in control panel.
   h. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.
   i. Instrumentation: Suction and discharge pressure gages.
   j. Light: Running light for pump.
   k. Thermal-bleed cutoff.
   l. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.
   m. High-suction-pressure cutout.
   n. Low-discharge-pressure cutout.
   o. High-discharge-pressure cutout.
   p. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 15 Section "Hvac Instrumentation And Controls". Include the following:
      1) On-off status of each pump.
      2) Alarm status.
9. Base: Structural steel.

D. Multiplex, Variable-Speed Booster Pumps
1. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
2. Pumps:
   a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
   b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
   c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
   d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
   e. Seal: Mechanical.
   f. Orientation: Mounted horizontally or vertically.
3. Pumps:
   a. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, frame-mounted, separately coupled, single-stage, overhung-impeller, centrifugal pump. Include back-pullout design, **as directed**.
   b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.

c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve and deflector.
e. Seal: Mechanical.
f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
g. Coupling: Flexible, with metal guard.

4. Pumps:
   a. Type: In line, single stage as defined in HI 1.1-1.2 and HI 1.3 for in-line, single-stage, close-coupled, overhung-impeller, centrifugal pump.
   b. Casing: Radially split; bronze **OR** cast iron **OR** stainless steel, **as directed**.
   c. Impeller: Closed, ASTM B 584 cast bronze **OR** stainless steel, **as directed**; statically and dynamically balanced and keyed to shaft.
   d. Shaft and Shaft Sleeve: Stainless-steel or steel, **as directed**, shaft, with copper-alloy shaft sleeve.
   e. Seal: Mechanical.
   f. Bearing: Grease-lubricated or pre-greased, permanently shielded ball type.
5. Pumps:
   a. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
   b. Casing: Cast-iron or steel base and stainless-steel chamber.
   c. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
   d. Shaft: Stainless steel.
   e. Seal: Mechanical.
   f. Bearing: Water-lubricated sleeve type.
6. Pumps:
   a. Type: Vertical, can, as defined in HI 2.1-2.2 and HI 2.3 for in-line, barrel or can, lineshaft, vertical pump.
   b. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
   c. Bowls: Epoxy-coated cast iron **OR** Cast iron, **as directed**.
   d. Shaft: Stainless steel.
   e. Seals: Mechanical and stuffing-box types.
   f. Bearings: Water-lubricated bushing type.
7. Motors: Single speed, with grease-lubricated or pre-greased, permanently shielded, ball-type bearings. Select motors that will not overload through full range of pump performance curve.
8. Piping: Copper tube and copper fittings **OR** Stainless-steel pipe and fittings **OR** Stainless-steel pipe and fitting headers and copper tube and copper fittings between headers and pump **OR** Galvanized-steel pipe and cast-iron fittings, **as directed**.
9. Valves:
   a. Shutoff Valves NPS 2 (DN 50) and Smaller: Gate valve or two-piece, full-port ball valve, in each pump's suction and discharge piping.
   b. Shutoff Valves NPS 2-1/2 (DN 65) and Larger: Gate valve or lug-type butterfly valve, in each pump's suction and discharge piping and in inlet and outlet headers, **as directed**.
   c. Check Valves NPS 2 (DN 50) and Smaller: Silent or swing type in each pump's discharge piping.
   d. Check Valves NPS 2-1/2 (DN 65) and Larger: Silent type in each pump's discharge piping.
   e. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
10. Dielectric Fittings: With insulating material isolating joined dissimilar metals.
11. Control Panel: Factory installed and connected as an integral part of booster pump; automatic for multiple-pump, variable-speed operation, with load control and protection functions.
    a. Control Logic: Solid-state system with transducers, programmable microprocessor, VFC, and other devices in controller. Install VFC for pump motors larger than 25 hp in separate panel; same type as motor control panel enclosure.
    b. Motor Controller: NEMA ICS 2, variable-frequency, solid-state type.

1) Control Voltage: 24 **OR** 120, **as directed**,-V ac, with integral control-power transformer.

c. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 4 **OR** Type 12, **as directed**.

d. Motor Overload Protection: Overload relay in each phase.

e. Starting Devices: Hand-off-automatic selector switch for each pump in cover of control panel, plus pilot device for automatic control.

1) Duplex, Automatic, Alternating Starter: Switches lead pump to lag main pump and to two-pump operation.

2) Triplex, Sequence (Lead-Lag-Lag) Starter: Switches lead pump to one lag main pump and to three-pump operation.

f. Pump Operation and Sequencing: Pressure-sensing method or flow-sensing method **OR** Pressure-sensing method for lead pump and flow-sensing method for lag pumps, **as directed**.

1) Time Delay: Controls pump on-off operation; adjustable from 1 to 300 seconds.

g. VFC: Voltage-source, pulse-width, modulating-frequency converter for each **OR** lead, **as directed**, pump.

h. Manual Bypass: Magnetic contactor arranged to transfer to constant-speed operation upon VFC failure.

i. Instrumentation: Suction and discharge pressure gages.

j. Lights: Running light for each pump.

k. Alarm Signal Device: Sounds alarm when backup pumps are operating.

1) Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic **OR** manual, **as directed**, reset.

l. Thermal-bleed cutoff.

m. Low-suction-pressure **OR** Water-storage-tank, low-level, **as directed**, cutout.

n. High-suction-pressure cutout.

o. Low-discharge-pressure cutout.

p. High-discharge-pressure cutout.

q. Building Automation System Interface: Provide auxiliary contacts for interface to BACnet **OR** LonWorks, **as directed**, building automation system. Building automation systems are specified in Division 15 Section "Hvac Instrumentation And Controls". Include the following:

1) On-off status of each pump.

2) Alarm status.

12. Base: Structural steel.

E. Motors

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.

1.3 EXECUTION

A. Examination

1. Examine roughing-in for booster pumps to verify actual locations of piping connections before booster-pump installation.

B. Installation

1. Equipment Mounting: Install booster pumps on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete", **as directed**.

a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
e. Install anchor bolts to elevations required for proper attachment to supported equipment.

2. Equipment Mounting: Install booster pumps using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
3. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

C. Connections
1. Comply with requirements for piping specified in Division 15 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers **OR** piping, **as directed**.
   a. Install shutoff valves on piping connections to booster-pump suction and discharge headers **OR** piping, **as directed**. Install ball, butterfly, or gate valves same size as suction and discharge headers **OR** piping, **as directed**. Comply with requirements for general-duty valves specified in Division 15 Section "General-duty Valves For Plumbing Piping".
   b. Install union, flanged, or grooved-joint connections on suction and discharge headers **OR** piping, **as directed**, at connection to domestic-water piping. Comply with requirements for unions and flanges specified in Division 15 Section "Domestic Water Piping".
   c. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers **OR** piping, **as directed**. Comply with requirements for domestic-water piping specified in Division 15 Section "Domestic Water Piping".
   d. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers **OR** piping, **as directed**. Comply with requirements for flexible connectors specified in Division 15 Section "Domestic Water Piping".
   e. Install piping adjacent to booster pumps to allow service and maintenance.

D. Identification
1. Identify system components. Comply with requirements for identification specified in Division 15 Section "Identification For Plumbing Piping And Equipment".

E. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Perform visual and mechanical inspection.
   b. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pumps and controls will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

F. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.

G. Adjusting
   1. Adjust booster pumps to function smoothly, and lubricate as recommended by manufacturer.
   2. Adjust pressure set points.
   3. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

H. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain booster pumps.

END OF SECTION 15230a

SECTION 15262 - HVAC WATER TREATMENT

A. Description Of Work
   1. This specification covers the furnishing and installation of materials for HVAC water treatment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work

B. Summary
   1. This Section includes the following HVAC water-treatment systems:
      a. Bypass chemical-feed equipment and controls.
      b. Biocide chemical-feed equipment and controls.
      c. Ozone-generator biocide equipment and controls.
      d. UV-irradiation unit, biocide equipment, and controls.
      e. Chemical treatment test equipment.
      f. HVAC water-treatment chemicals.
      g. Makeup water softeners.
      h. RO equipment for HVAC makeup water.
      i. Water filtration units for HVAC makeup water.

C. Definitions
   1. EEPROM: Electrically erasable, programmable read-only memory.
   2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
   3. RO: Reverse osmosis.
   4. TDS: Total dissolved solids.
   5. UV: Ultraviolet.

D. Performance Requirements
   1. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
   2. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
   3. Closed hydronic systems, including hot-water heating, chilled water, dual-temperature water, and glycol cooling, shall have the following water qualities:
      a. pH: Maintain a value within 9.0 to 10.5.
      b. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
      c. Boron: Maintain a value within 100 to 200 ppm.
      d. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
      e. Soluble Copper: Maintain a maximum value of 0.20 ppm.
      f. TDS: Maintain a maximum value of 10 ppm.
      g. Ammonia: Maintain a maximum value of 20 ppm.
      h. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
      i. Microbiological Limits:
         1) Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
         2) Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
         3) Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
         4) Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
         5) Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
   4. Steam Boiler and Steam Condensate:
      a. Steam Condensate:
         1) pH: Maintain a value within 7.8 to 8.4.
         2) Total Alkalinity: Maintain a value within 5 to 50 ppm.

3) Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
4) Soluble Copper: Maintain a maximum value of 0.20 ppm.
5) TDS: Maintain a maximum value of 10 ppm.
6) Ammonia: Maintain a maximum value of 20 ppm.
7) Total Hardness: Maintain a maximum value of 2 ppm.

b. Steam boiler operating at 15 psig (104 kPa) and less shall have the following water qualities:
1) "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
2) TDS: Maintain a value within 600 to 3000 ppm.

c. Steam boiler operating at more than 15 psig (104 kPa) shall have the following water qualities:
1) "OH" Alkalinity: 200 to 400 ppm.
2) TDS: Maintain a value within 600 to 1200 ppm to maximum 30 times RO water TDS.

5. Open hydronic systems, including condenser **OR** fluid-cooler spray, **as directed**, water, shall have the following water qualities:
a. pH: Maintain a value within 8.0 to 9.1.
b. "P" Alkalinity: Maintain a maximum value of 100 ppm.
c. Chemical Oxygen Demand: Maintain a maximum value of 100ppm.
d. Soluble Copper: Maintain a maximum value of 0.20 ppm.
e. TDS: Maintain a maximum value of 10 ppm.
f. Ammonia: Maintain a maximum value of 20 ppm.
g. Free "OH" Alkalinity: Maintain a maximum value of 0 ppm.
h. Microbiological Limits:
1) Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.
2) Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
3) Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
4) Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
5) Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
i. Polymer Testable: Maintain a minimum value within 10 to 40.

6. Passivation for Galvanized Steel: For the first 60 days of operation.
a. pH: Maintain a value within 7 to 8.
b. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
c. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
a. Wiring Diagrams: Power and control wiring.
3. Field quality-control test reports.
4. Manufacturer Seismic Qualification Certification
5. Other Informational Submittals:
a. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
b. Water Analysis: Illustrate water quality available at Project site.
c. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to the Owner.

F. Quality Assurance
1. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Manual Chemical-Feed Equipment
1. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
a. Capacity: 2 gal. (7.6 L) **OR** 5 gal. (19 L), **as directed**.
b. Minimum Working Pressure: 125 psig (860 kPa) **OR** 175 psig (1210 kPa), **as directed**.

B. Automatic Chemical-Feed Equipment
1. Water Meter:
a. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
b. Body: Bronze.
c. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
d. Registration: Gallons (Liters) or cubic feet (cubic meters).
e. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
2. Water Meter:
a. AWWA C701, turbine-type, totalization meter.
b. Body: Bronze.
c. Minimum Working-Pressure Rating: 100 psig (690 kPa).
d. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
e. Registration: Gallons (Liters) or cubic feet (cubic meters).
f. End Connections: Threaded.
g. Control: Low-voltage signal capable of transmitting 1000 feet (305 m).
3. Water Meter:

4. AWWA C701, turbine-type, totalization meter.
a. Body: Bronze **OR** Epoxy-coated cast iron, **as directed**.
b. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
c. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
d. Registration: Gallons (Liters) or cubic feet (cubic meters).
e. End Connections: Flanged.
f. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
5. Inhibitor Injection Timers:
a. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 15 Section "Hvac Instrumentation And Controls".
b. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
c. Test switch.
d. Hand-off-auto switch for chemical pump.
e. Illuminated legend to indicate feed when pump is activated.
f. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
g. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
6. pH Controller:

a. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 15 Section "Hvac Instrumentation And Controls".
b. Digital display and touch pad for input.
c. Sensor probe adaptable to sample stream manifold.
d. High, low, and normal pH indication.
e. High or low pH alarm light, trip points field adjustable; with silence switch.
f. Hand-off-auto switch for acid pump.
g. Internal adjustable hysteresis or deadband.

7. TDS Controller:
   a. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 15 Section "Hvac Instrumentation And Controls".
   b. Digital display and touch pad for input.
   c. Sensor probe adaptable to sample stream manifold.
   d. High, low, and normal conductance indication.
   e. High or low conductance alarm light, trip points field adjustable; with silence switch.
   f. Hand-off-auto switch for solenoid bleed-off valve.
   g. Bleed-off valve activated indication.
   h. Internal adjustable hysteresis or deadband.
   i. Bleed Valves:
      1) Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
      2) Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.
8. Biocide Feeder Timer:
   a. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 15 Section "Hvac Instrumentation And Controls".
   b. 24-hour timer with 14-day skip feature to permit activation any hour of day.
   c. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
   d. Solid-state alternator to enable use of two different formulations.
   e. 24-hour display of time of day.
   f. 14-day display of day of week.
   g. Battery backup so clock is not disturbed by power outages.
   h. Hand-off-auto switches for biocide pumps.
   i. Biocide A and Biocide B pump running indication.
9. Chemical Solution Tanks:
   a. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
   b. Molded cover with recess for mounting pump.
   c. Capacity: 30 gal. (114 L) **OR** 50 gal. (189 L) **OR** 120 gal. (454 L), **as directed**.
10. Chemical Solution Injection Pumps:
   a. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
   b. Adjustable flow rate.
   c. Metal and thermoplastic construction.
   d. Built-in relief valve.
   e. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

11. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.
12. Injection Assembly:
    a. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
    b. Ball Valve: Three **OR** Two, **as directed**,-piece, stainless steel; selected to fit quill.
    c. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
    d. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

C. Ozone-Generator Biocide Equipment
1. Corona discharge generator with stainless-steel generating cells, and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Provide site glasses to verify proper operation of generator.
2. Water-cooled generators shall be provided with cooling water at maximum 70 deg F (21 deg C) and 35 psig (241 kPa).
3. Generator vessels exposed to system pressure shall be constructed according to ASME Boiler and Pressure Vessel Code and be equipped with pressure relief valve.
4. External air compressor or induced airflow through a cleanable prefilter supplies concentrated oxygen through a molecular sieve with minus 62 deg F (minus 52 deg C) dew point to avoid the formation of nitric acid.
5. Microprocessor-based control with software in EEPROM, surge protection, high-temperature cutout, and operational status lights. Interface for start/stop and status indication at central workstation as described in Division 15 Section "Hvac Instrumentation And Controls".
6. Ozone Contactors:
    a. Bubble diffusers.
    b. Induction injection nozzle.
    c. Injectors with static mixers.
7. Ozone Detector and Alarm Devices:
    a. Detector:
        1) Sensor: Metal dioxide semiconductor.
        2) Concentration Range: 0.01 to 0.14 ppm.
        3) Accuracy: Plus or minus 20 percent of range.
        4) Sensitivity: 0.01 ppm.
        5) Response Time: Maximum 10 seconds.
        6) Operating Temperature: 50 to 100 deg F (10 to 38 deg C).
        7) Relatively Humidity: 20 to 95 percent, noncondensing over the operating temperature range.
    b. Horns:
        1) Electric-vibrating-polarized type.
        2) 24-V dc; with provision for housing the operating mechanism behind a grille.
        3) Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn.
    c. Visible Alarm Devices:
        1) Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.
        2) Rated Light Output: 75 **OR** 110, **as directed**, candela.
        3) Strobe Leads: Factory connected to screw terminals.
8. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand, compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.
    a. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in

mask, close-fitting nose piece to ensure no CO_2 buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.

b. Backplate: Orthopedically designed of chemical and impact-resistant, glass-fiber composite **OR** aluminum, **as directed**.

c. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps. Modular in design, detachable components, and easy to clean and maintain. Shoulder straps padded with flame-resistant material, reinforced with stainless-steel cable, and attached with T-nuts, washers, and screws.

d. Air Cylinder: 30 **OR** 45 **OR** 60, **as directed**,-minute, low-pressure, air-supply-loaded fiberglass **OR** aluminum **OR** steel, **as directed**, cylinders fitted with quick-fill assembly for refilling and air transfer.

e. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.

f. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, according to 42 CFR 84, Subpart H.

D. Stainless-Steel Pipes And Fittings

1. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.
2. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.
3. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig (1725-kPa) SWP and 600-psig (4140-kPa) CWP ratings.
4. Three-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and 150-psig (1035-kPa) SWP and 600-psig (4140-kPa) CWP rating.

E. UV Biocide Equipment

1. Target Irradiation: Minimum 30,000 microwatts x s/sq. cm.
2. Light Source Vessels:
   a. ASTM A 666, Type 304 stainless steel.
   b. Construct for minimum 150 psig (1035 kPa) at 150 deg F (65 deg C) according to ASME Boiler and Pressure Vessel Code, and equipped with pressure relief valve.
   c. Light Source Sleeve: Quartz, with EPDM O-ring seals.
   d. Light Source: Replaceable UV lamp producing minimum target irradiation of 254-nm wavelength light.
3. Controls: Interlock with pumps to operate when water is circulating.

F. Chemical Treatment Test Equipment

1. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
2. Sample Cooler:
   a. Tube: Sample.
      1) Size: NPS 1/4 (DN 8) tubing.
      2) Material: ASTM A 666, Type 316 stainless steel.
      3) Pressure Rating: Minimum 2000 psig (13 790 kPa).
      4) Temperature Rating: Minimum 850 deg F (454 deg C).
   b. Shell: Cooling water.
      1) Material: ASTM A 666, Type 304 stainless steel.
      2) Pressure Rating: Minimum 250 psig (1725 kPa).
      3) Temperature Rating: Minimum 450 deg F (232 deg C).
   c. Capacities and Characteristics:
      1) Tube: Sample.
         a) Flow Rate: 0.25 gpm (0.016 L/s).

b) Entering Temperature: 400 deg F (204 deg C).
c) Leaving Temperature: 88 deg F (31 deg C).
d) Pressure Loss: 6.5 psig (44.8 kPa).
2) Shell: Cooling water.
a) Flow Rate: 3 gpm (0.19 L/s).
b) Entering Temperature: 70 deg F (21 deg C).
c) Pressure Loss: 1.0 psig (6.89 kPa).

3. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
   a. Two-station rack for closed-loop systems.
   b. Four-station rack for open systems.

G. Chemicals
1. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1.1 "Performance Requirements" Article.
2. Water Softener Chemicals:
   a. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
   b. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

H. HVAC Makeup Water Softener
1. Description: Twin mineral tanks and one brine tank, factory mounted on skid.
2. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
3. Mineral Tanks:
   a. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   b. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
   c. Pressure Rating: 100 psig (690 kPa) **OR** 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
   d. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C).
   e. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
   f. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
   g. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
   h. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
   i. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.
4. Controls: Automatic; factory mounted on mineral tanks and factory wired.
   a. Adjustable duration of regeneration steps.
   b. Push-button start and complete manual operation override.
   c. Pointer on pilot-control valve shall indicate cycle of operation.
   d. Means of manual operation of pilot-control valve if power fails.
   e. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

1) Slow opening and closing, nonslam operation.
2) Diaphragm guiding on full perimeter from fully open to fully closed.
3) Isolated dissimilar metals within valve.
4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
5) Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
6) Sampling cocks for soft water.

f. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons (liters), and automatically resets after regeneration to preset total in gallons (liters) for next service run. Include alternator to regenerate one mineral tank with the other in service.

5. Brine Tank: Combination measuring and wet-salt storing system.
   a. Tank and Cover Material: Fiberglass a minimum of 3/16 inch (4.8 mm) thick; or molded PE a minimum of 3/8 inch (9.5 mm) thick.
   b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
   c. Size: Large enough for at least four regenerations at full salting.
6. Factory-Installed Accessories:
   a. Piping, valves, tubing, and drains.
   b. Sampling cocks.
   c. Main-operating-valve position indicators.
   d. Water meters.
7. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.

I. RO Equipment For HVAC Makeup Water
1. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.
2. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
3. Skid Assembly: Welded-steel frame coated with epoxy protective finish.
4. RO Membrane and Housing:
   a. Element: Thin-film composite with U-cup brine seal with minimum 98 percent salt rejection based on 2000-ppm water supplied at 225 psig (1551 kPa) and 77 deg F (25 deg C).
   b. Housing: ASTM A 666, Type 304 stainless steel with PVC end caps held in place with stainless-steel straps.
5. High-Pressure Pumps and Motors:
   a. Pump:
      1) Vertical, multistage centrifugal operating at 3500 rpm with ASTM A 666, Type 304 stainless-steel casing, shaft, impellers, and inlet and discharge casting.
      2) Bearings shall be tungsten carbide and ceramic.
      3) Cast-iron frame and flanged suction and discharge connections.
   b. Motor: NEMA-standard, C-faced TEFC motor supported on the pump-bearing frame. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
6. Controls:
   a. Microprocessor-based controller with LCD display.
   b. Interlock for remote start/stop control.
   c. Membrane flush sequence when pumps shut down.
   d. Run time indicator.
   e. Low-pressure safety cutoff.
   f. Panel-mounted gages as follows:

1) Product and concentrate.
2) Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
3) Product conductivity monitor.

7. Valves:
   a. Stainless-steel pump, concentrate, and recycle throttling valves rated for minimum 300 psig (2068 kPa).
   b. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
   c. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Sample valves at cartridge filter outlet, concentrate, and product outlet.
8. Prefilter:
   a. Housing: Polypropylene with built-in relief or vent valve.
   b. Element: Spun-wound polypropylene.
9. Inlet Water Tempering Valve: Thermostatic water-tempering valve to maintain 77 deg F (25 deg C), **as directed**, inlet water temperature to RO unit.
10. Activated Carbon Filter:
    a. Media Tank: Fiberglass-reinforced polyester rated for minimum 150 psig (1035 kPa) with internal backwash distributor and filtered water collector.
    b. Media: 12 x 40-mesh, bituminous coal-based activated carbon.
    c. Backwash Valve: Piston-operated control valve with drain-line, flow-control orifice.
    d. Backwash Control: Seven-day time clock.
11. Atmospheric Storage Tank:
    a. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
    b. Control: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps, and signal an alarm.
12. Repressurization Pumps:
    a. Pumps: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components ASTM A 666, Type 316 stainless steel.
    b. Controls: NEMA-4X pump control panel constructed of fiberglass to control pumps, one operating, one standby, with automatic alternator and fail-over control.
    c. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
13. Water Test Kit: Include water test kit in wall-mounting cabinet for RO unit.

J. Filtration Equipment
1. Multimedia Filters:
   a. Description: Factory-fabricated and -tested, simplex, multimedia filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.
      1) Filter Tank: Corrosion resistant with distribution system and media.
         a) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
         b) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
         c) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
         d) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
         e) FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; Designation E, 125-psig (0.862-MPa) or F, 150-psig (1.034-MPa) pressure category flanges of grade same as tank material according to ASTM D 5421.

2) Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
3) Strainer: Basket type mounted on pump suction.
4) Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
5) Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
6) Safety Valves: Automatic pressure relief.
7) Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
   a) Casing: Radially split, cast iron.
   b) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
   c) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
   d) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
   e) Seal: Mechanical.
   f) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
8) Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.
   a) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.
   b) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
   c) Backwash: Automatic; with time clock and differential pressure switch.
   d) Backwash Valve: Tank mounted with valves interlocked to single actuator.
9) Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.

2. Self-Cleaning Strainers:
   a. Description: Factory-fabricated and -tested, ASTM A 126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.
      1) Fabricate and label ASTM A 126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
      2) Pipe Connections:
         a) NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
   b. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
   c. Strainer: ASTM A 666, Type 316 stainless steel.
   d. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
   e. Safety Valves: Automatic pressure relief.
   f. Backwash Arm Drive:
      1) Drive Casing: Cast iron.
      2) Worm Gears: Immersed in oil.
      3) Motor: ODP motor supported on the strainer-bearing frame. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   g. Controls: Automatic control of backwash; factory wired for single electrical connection.
      1) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.

2) Backwash Arm Drive: Automatic and manual switching; manual switch position bypasses safeties and controls.
3) Backwash: Automatic; with time clock and differential pressure switch.
4) Backwash Valve: Electric actuator.

h. Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event when strainer base is anchored to building structure.

3. Bag **OR** Cartridge, **as directed**,-Type Filters:

a. Description: Floor-mounting housing with filter bags **OR** cartridges, **as directed**, for removing particles from water.

1) Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through bag **OR** cartridge, **as directed**,-type water filter; with bag support and base, feet, or skirt.

a) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
b) Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
c) Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: 150-psig (1035-kPa) plastic flanges.

2) Bag **OR** Cartridge, **as directed**: Replaceable; of shape to fit housing.

4. Centrifugal Separators:

a. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.

b. Housing: With manufacturer's proprietary system of baffles and chambers.

1) Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2) Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
3) Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
4) Collection Chamber: Designed to hold separated particles.
5) Outlet: Near top of unit.
6) Purge: At bottom of collection chamber.
7) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
8) Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.

c. Motorized Purge Valve: Gate or plug pattern valve.

1) Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.

d. Strainer: Stainless-steel basket type mounted on pump suction.

e. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.

f. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.

g. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.

1) Casing: Radially split, cast iron.
2) Pressure Rating: 125 psig (860 kPa) **OR** 150 psig (1035 kPa), **as directed**, minimum.
3) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
4) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
5) Seal: Mechanical.

6) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

h. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.
   1) Panel: NEMA 250, Type 4 enclosure.
   2) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
   3) Separator Purge: Automatic and manual.
   4) TDS Controller Interlock: Open separator purge valve with bleed-off control.

i. Support: Skid mounting. Fabricate supports and base and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.

1.3 EXECUTION

A. Water Analysis
   1. Perform an analysis of supply water to determine quality of water available at Project site.

B. Installation
   1. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
   2. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
   3. Install water testing equipment on wall near water chemical application equipment.
   4. Install interconnecting control wiring for chemical treatment controls and sensors.
   5. Mount sensors and injectors in piping circuits.
   6. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water, dual-temperature water, and glycol cooling, and equipped with the following:
      a. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
      b. Install water meter in makeup water supply.
      c. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
      d. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
      e. Install a swing check on inlet after the isolation valve.
   7. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:
      a. Install makeup water softener.
      b. Install water meter in makeup water supply.
      c. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
         1) Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
      d. Install test equipment and furnish test-kit to Owner.
      e. Install RO unit for makeup water.
      f. Install TDS controller with sensor and bleed valves.
         1) Bleed valves shall cycle to maintain maximum TDS concentration.
      g. Install inhibitor injection timer with injection pumps and solution tanks.

1) Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.

8. Install automatic chemical-feed equipment for condenser **OR** fluid-cooler spray, **as directed**, water and include the following:
   a. Install makeup water softener.
   b. Install water meter in makeup water supply.
   c. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
      1) Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
   d. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
   e. Install TDS controller with sensor and bleed valves.
      1) Bleed valves shall cycle to maintain maximum TDS concentration.
   f. Install pH sensor and controller with injection pumps and solution tanks.
      1) Injector pumps shall operate to maintain required pH.
   g. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
      1) Injection pumps shall operate to feed biocide on an alternating basis.
   h. Install ozone generator with diffusers in condenser-water piping.
   i. Ozone generator shall operate continuously with condenser-water flow.
   j. Install UV-irradiation lamps in condenser-water piping.
      1) UV lights shall operate continuously with condenser-water flow.

C. Ozone-Generator Installation
   1. Install ozone generator and equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
   2. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
   3. Pipe ozone from ozone generator to condenser water with stainless-steel pipe and fittings with welded joints.
   4. Install two **OR** three, **as directed**,-piece, stainless-steel ball valve in ozone supply to condenser water.
   5. Pipe cooling water to ozone generator, and to air-gap drain fitting with stainless-steel pipe and fittings with welded joints where enclosed in ozone-generator room.
   6. Install two **OR** three, **as directed**,-piece, stainless-steel ball valve in cooling water supply to ozone generator.
   7. Mounting supports for ozone generator shall be ASTM A 666, Type 316 stainless steel.
   8. Mount breathing apparatus outside ozone-generator room.
   9. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.

D. UV-Irradiation Unit Installation
   1. Install UV-irradiation units on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
   2. Install seismic restraints for UV-irradiation units and floor-mounting accessories and anchor to building structure. Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.

E. Water Softener Installation

1. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
2. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.
4. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
5. Install water-testing sets on wall adjacent to water softeners.

F. RO Unit Installation
1. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.
2. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.
4. Install water testing sets on wall adjacent to RO unit.

G. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.
3. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 15 Section "Common Work Results For Hvac".
4. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 15 Section "General-duty Valves For Hvac Piping".
5. Refer to Division 15 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.
6. Confirm applicable electrical requirements in Division 15 for connecting electrical equipment.
7. Ground equipment according to Division 16 Section "Grounding And Bonding".
8. Connect wiring according to Division 16 Section "Conductors And Cables".

H. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
   a. Inspect field-assembled components and equipment installation, including piping and electrical connections.
   b. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
   c. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
   d. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

e. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
f. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
g. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
h. Repair leaks and defects with new materials and retest piping until no leaks exist.

4. Remove and replace malfunctioning units and retest as specified above.
5. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four **OR** six **OR** eight, **as directed**,-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.
6. At four **OR** six **OR** eight, **as directed**,-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1.1 "Performance Requirements" Article.
7. Comply with ASTM D 3370 and with the following standards:
   a. Silica: ASTM D 859.
   b. Steam System: ASTM D 1066.
   c. Acidity and Alkalinity: ASTM D 1067.
   d. Iron: ASTM D 1068.
   e. Water Hardness: ASTM D 1126.

I. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION 15262

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Task	Specification	Specification Description
15262	15061f	Hydronic Piping
15270	01352	No Specification Required
15270	02455a	Water Distribution
15270	15080	Meters and Gages for Plumbing Piping
15270	15080a	Meters and Gages for HVAC Piping

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SECTION 15310 - PACKAGED SEWAGE PUMPING STATIONS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for packaged sewage pumping stations. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes dry-well, packaged pumping stations with dry-well or vacuum-primed sewage pumps.
2. This Section includes wet-well, packaged pumping stations with submersible or submersible grinder or wet-well-mounting sewage pumps.

C. Performance Requirements
1. Pressure Rating of Sewage Pumps and Discharge Piping Components: At least equal to sewage pump discharge pressure, but not less than 125 psig (860 kPa).
2. Pressure Rating of Other Piping Components: At least equal to system operating pressure.

D. Submittals
1. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
2. Shop Drawings: Show fabrication and installation details for each packaged pumping station. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   a. Wiring Diagrams: Power, signal, and control wiring.
3. Product Certificates: For sewage pumps, signed by product manufacturer.
4. Manufacturer Seismic Qualification Certification
5. Field quality-control test reports.
6. Maintenance Data: For packaged pumping stations to include in maintenance manuals.

E. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Testing Agency Qualifications: Nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with HI 1.1-1.2, "Centrifugal Pumps for Nomenclature and Definitions"; HI 1.3, "Centrifugal Pumps for Design and Application"; and HI 1.4, "Centrifugal Pumps for Installation, Operation and Maintenance," for sewage and sump pumps.
5. Comply with UL 778, "Motor-Operated Water Pumps," for sewage and sump pumps.

F. Project Conditions
1. Interruption of Existing Sanitary Sewer Service: Do not interrupt sanitary sewer service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sanitary sewer service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of sanitary sewer service.

b. Do not proceed with interruption of sanitary sewer service without Owner's written permission.

1.2 PRODUCTS

A. Dry-Well, Packaged Sewage Pumping Stations

1. Dry-Well, Packaged Sewage Pumping Stations with Dry-Well Sewage Pumps:

a. Description: Factory fabricated, assembled, and tested with wet well for comminutor and collection of sanitary sewage and with dry equipment chamber for sewage pumps, controls, and accessories.

1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.

2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.

3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.

4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).

5) Comminutor: Full size of sewage inlet pipe.

6) Sewage Pumps: Two **OR** Three, **as directed**, dry-well-type, nonclog sewage pumps with controls and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; mechanical or stuffing-box seals; and pedestal-mounted motor.

2. Dry-Well, Packaged Sewage Pumping Stations with Vacuum-Primed Sewage Pumps:

a. Description: Factory fabricated, assembled, and tested with wet well for comminutor and collection of sanitary sewage and with dry equipment chamber for sewage pumps, vacuum pumps, controls, and accessories.

1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.

2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.

3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.

4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).

5) Comminutor: Full size of sewage inlet pipe.

6) Sewage Pumps: Two **OR** Three, **as directed**, dry-chamber-mounting, vacuum-primed, nonclog sewage pumps located in dry compartment above wet pit, with controls and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; mechanical or stuffing-box seals; pedestal-mounted motor; and suction piping extending to bottom of wet pit.

7) Vacuum Pumps: Duplex arrangement with controls, vacuum piping, and vent piping of size and capacity required for system. Include automatic alternator, with manual disconnect switch, to change sequence of lead-lag vacuum pumps at completion of each cycle.

B. Wet-Well, Packaged Sewage Pumping Stations

1. Wet-Well, Packaged Sewage Pumping Stations with Submersible Sewage Pumps:

a. Description: Factory fabricated, assembled, and tested with wet well for comminutor, sewage pumps and collection of sanitary sewage and with sewage pumps and dry equipment chamber for controls and accessories.

1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
5) Comminutor: Full size of sewage inlet pipe.
6) Sewage Pumps: Two **OR** Three, **as directed**, submersible-type sewage pumps, with guide rail, quick-disconnect system, controls, and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.

2. Wet-Well, Packaged Sewage Pumping Stations with Submersible Grinder Sewage Pumps:
   a. Description: Factory fabricated, assembled, and tested with wet well for sewage pumps and collection of sanitary sewage and with dry equipment chamber for controls and accessories.
      1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
      2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
      3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
      4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
      5) Sewage Pumps: Two **OR** Three, **as directed**, submersible grinder-type sewage pumps, with guide rail, quick-disconnect system, controls, and piping. Include stainless-steel grinder impeller and hermetically sealed motor with moisture-sensing probe, mechanical seals, and waterproof power cable.
         a) If Project has more than one wet-well, packaged sewage pumping station with submersible grinder sewage pumps,
3. Wet-Well, Packaged Sewage Pumping Stations with Wet-Well-Mounting Sewage Pumps:
   a. Description: Factory fabricated, assembled, and tested with wet well for comminutor, sewage pumps and collection of sanitary sewage and with suspended sewage pumps and dry equipment chamber for pump motors, controls, and accessories.
      1) Orientation: Shell underground with dry equipment chamber underground with top flush with grade **OR** partially recessed underground **OR** above grade **OR** underground with entrance tube to grade, **as directed**.
      2) Shell: Factory fabricated from structural-steel plate **OR** fiberglass, **as directed**.
      3) Entrance Tube: From dry compartment to entrance at grade, and of size required to replace largest piece of equipment, but not smaller than 36 inches (914 mm) in diameter.
      4) Cathodic Protection: as directed by the Owner, exterior magnesium anode(s).
      5) Comminutor: Full size of sewage inlet pipe.
      6) Sewage Pumps: Two **OR** Three, **as directed**, wet-well-mounting-type, nonclog sewage pumps suspended from dry-compartment floor, with controls and piping. Include ASTM A 48/A 48M, Class 25, nonclog, cast-iron impeller capable of passing solids of 3-inch (76-mm) minimum diameter; grease-lubricated bearings and stuffing-box seal; shaft coupling; and pedestal-mounted motor.

C. Comminutors:
   1. Description: Motor-operated, single- or twin-shaft, cutter- or grinder-design unit with controls; for pipeline installation.
      a. Body: Stainless steel or ductile iron with flanged ends and access plate.

b. Cutting Elements: Motor-driven rotor and stationary cutters or grinders of hardened stainless or heat-treated steel.
c. Motor: Explosion proof, directly connected to body.
d. Control Panel: NEMA 250, Type 12 enclosure for installation in dry equipment chamber.

D. Controls
1. Control Sequence of Operation: Cycle each sewage pump on and off automatically to maintain wet-well sewage level. Automatic control operates both pumps in parallel if wet-well level rises above starting point of low-level pump, until shutoff level is reached. Automatic alternator, with manual disconnect switch, changes sequence of lead-lag sewage pumps at completion of each pumping cycle.
2. Self-Purging, Air-Bubbler System: Senses variations of sewage level in wet well. Include duplex-arrangement oilless air compressors to furnish bubbler air; filters; air-storage reservoir; piping; airflow meter with needle valve adjustment for airflow regulation; sewage depth gage; air-bubbler piping to wet well; and pressure-sensing, dustproof mercury switches.
3. Electrode **OR** Float-Switch **OR** Pressure-Switch **OR** Ultrasonic, **as directed**, System: Senses variations of sewage level in wet well. Include high and low adjustments capable of operating on 6-inch (150-mm) minimum differential of liquid level.
4. Motor Controllers: Magnetic, full voltage, nonreversing. Include undervoltage release, thermal-overload heaters in each phase, manual reset buttons, and hand-automatic selector switches. Include circuit breakers to provide branch-circuit protection for each controller.
5. 120-V accessory controls with 15-A, single-phase circuit breakers or fuses for each item.
6. Control Panel: Enclosure complying with UL 508A and with UL 508A, Supplement SB, **as directed**, with separate compartments and covers for controllers, circuit breakers, transformers, alternators, and single-phase controls. Include 20-A duplex receptacle in NEMA WD 1, Configuration 5-20R mounted on exterior of control panel.
   a. Mounting: Inside, on dry-chamber wall **OR** Outside, on pedestal, at grade, **as directed**.
   b. Enclosure: NEMA 250, Type 1 **OR** 4 **OR** 4X, **as directed**.
7. Install labels on panel face to identify switches and controls.
8. Wiring: Tin-copper wiring.
9. Connection for Portable Generator: Nonautomatic (manual) transfer switch with receptacle matching generator electrical power requirements. Nonautomatic transfer switches are specified in Division 16 Section "Transfer Switches" and receptacles are specified in Division 16 Section "Wiring Devices".

E. Accessories
1. Lighting: Minimum of 2, UL 1571, heavy-duty, cast-metal, wet-location-type fixtures with 100-W bulbs and guards in service area. Locate switches, with pilot lights, at chamber entrance.
2. Submersible Sump Pump:
   a. Discharge Size: NPS 1-1/4 (DN 32) minimum.
   b. Pump End Bell and Motor Shell: Cast iron.
   c. Motor: 1/3 hp, 1750-rpm, hermetically sealed, capacitor-start, with built-in overload protection.
   d. Impeller: ASTM B 584, cast bronze or ASTM B 36/B 36M, brass.
   e. Shaft: Stainless steel.
   f. Bearings: Grease-lubricated, factory-sealed ball bearings.
   g. Seals: Mechanical.
   h. Accessories: Inlet strainer.
   i. Controls: Float switch.
3. Dehumidifier: Electric refrigeration system, adjustable humidistat, reverse-acting thermostat for low-temperature cutoff controls, and condensate pump with drain piping to sump.
   a. Dehumidification system capacity adequate to remove at least 15 pints (7 L) of water per day from service area air that is 80 deg F (27 deg C) with a relative humidity of 60 percent.
4. Ventilation: Electrically powered ventilation system. Include centrifugal blower with 4-inch- (100-mm-) round exhaust vent designed to keep out rain, insects, and other foreign matter; limit switch

to start blower if entrance door or lid is opened; 0- to 15-minute timer; and separate manual switch.
    a. Ventilating system capacity to change air in dry equipment chamber every two minutes.
5. Heater: Electric, 1.5 kW minimum, with fan and thermostat control.
6. High-Water Audio Alarm: Horn for audio indication of station high-water level, energized by separate level-detecting device. Include alarm silencer switch and relay in station.
7. Remote Alarm Circuit: Include contacts for connection to remote alarm panel.

F. Motors
1. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Plumbing Equipment".

G. Miscellaneous Materials
1. Structural Steel: ASTM A 6/A 6M, W or HP shapes, or ASTM A 36/A 36M, plates or beams.
2. Grout: ASTM C 1107, Grade B, nonshrink cement grout.
    a. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Concrete: Concrete is specified in Division 03 Section "Cast-in-place Concrete".

H. Packaged Sewage Pumping Station Fabrication
1. Fabricate shell from structural-steel plate with continuous welds to make watertight and gastight construction.
    a. Walls: 1/4-inch (6.4-mm) minimum thickness.
    b. Top and Bottom Heads: 3/8-inch (9.5-mm) minimum thickness. Weld reinforcing steel to top and bottom heads.
    c. Entrance-Tube Walls: 1/4-inch (6.4-mm) minimum thickness.
    d. Weld steel access ladder and air vent to shell and entrance tube, **as directed**.
    e. Apply three coats of epoxy resin to interior and exterior surfaces.
    f. Include at least two **OR** four, **as directed**, exterior magnesium anode(s) for cathodic protection.
2. Fabricate shell from fiberglass with structural-steel reinforcement.
    a. Attach structural-steel reinforcement to top and bottom heads.
    b. Fabricate shell with continuous joints to make watertight and gastight construction.
    c. Attach air vent to pump chamber and entrance tube, **as directed**.
    d. Ladder: Steel **OR** Fiberglass, **as directed**.
3. Install sump, 18 inches (450 mm) in diameter by 10 inches (254 mm) deep in dry-chamber floor. Slope floor toward sump and fasten rubber mat to floor walkway with cement.
4. Entrance tube may be furnished separately for field installation.
5. Entrance Cover: Waterproof and corrosion resistant, with lock. Include way to open cover from inside tube if cover is locked.
6. Air Vent: Duct fabricated from corrosion-resistant material, extended to above grade, outlet turned down, and with insect screen in outlet.
7. Factory fabricate piping between unit components.
    a. Use galvanized-steel pipe and cast-iron fittings or ductile-iron pipe and fittings.
    b. Use fittings for changes in direction and branch connections.
    c. Flanged and union joints may be used instead of joints specified.
    d. Use dielectric fittings for connections between ferrous- and copper-alloy piping.
8. Piping Connections: Unless otherwise indicated, make the following piping connections:
    a. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having NPS 2 (DN 50) or smaller threaded pipe connection.
    b. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
9. Valves: Ferrous alloy.
    a. Sewage Pump Piping: Include gate valve on each pump inlet and gate and check valves on each discharge pipe.
    b. Sump Pump Piping: Include ball or gate and check valves on discharge pipe.

c. Compressed-Air Piping: Include ball and check valves on discharge pipe from each air compressor.
d. Vacuum Piping: Include ball and check valves on inlet pipe to each vacuum pump.

10. Wiring: Tin-coated copper.

I. Source Quality Control
1. Test and inspect sewage and sump, **as directed**, pumps according to HI 1.6, "Centrifugal Pump Tests." Include test recordings that substantiate correct performance of pumps at design head, capacity, suction lift, speed, and horsepower.
2. Test accessories and controls through complete cycle. Include test recordings that substantiate correct performance.

1.3 EXECUTION

A. Earthwork
1. Excavation, trenching, and backfilling are specified in Division 02 Section "Earthwork".

B. Installation
1. Install packaged sewage pumping station components where indicated, according to specific equipment and piping arrangement indicated.
2. Shell Base Supports: Form from structural-steel beams, of number and lengths required to support bottom of shell and to anchor beams to concrete foundation.
a. Use elevator blocks attached to bottom of shell to slope station floor 1 inch in 10 feet (25.4 mm in 3 m) down toward sump.
3. Grout under and around shell. Ensure that there are no voids between foundation slab and underslab of pumping station.
4. Fill voids between shell sidewalls, sleeves, and piping and make watertight seal with grout.
5. Connect anode conductors to grounding lugs on steel housing.
6. Join separate sections of housing by field welding.
7. Field weld entrance tube to housing.

C. Connections
1. Sanitary sewer piping installation requirements are specified in Division 02 Section "Sanitary Sewerage". Drawings indicate general arrangement of piping.
2. Install piping adjacent to machine to allow service and maintenance.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Connect wiring according to Division 16 Section "Conductors And Cables".

D. Identification
1. Install identifying labels permanently attached to equipment.
2. Install operating instruction signs permanently attached to equipment or on pumping station wall near equipment.
3. Arrange for installing green warning tape or detectable warning tape over outside edges of underground packaged sewage pumping stations. Tape materials and their installation are specified in Division 02 Section "Earthwork".

E. Painting
1. Prepare and paint ferrous piping in wet wells, structural-steel supports, and anchor devices with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.
2. Paint field-welded areas to match factory coating.

F. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform field tests and inspections and prepare test reports.

2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.. Report results in writing.
3. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
   a. After installing packaged sewage pumping stations and after electrical circuitry has been energized, test for compliance with requirements. Furnish water required for pump tests.
   b. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Remove and replace packaged sewage pumping stations that do not pass tests and inspections and retest as specified above.

G. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Adjust pump, accessory, and control settings, and safety and alarm devices.

H. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged sewage pumping stations.

END OF SECTION 15310

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SECTION 15310a - LIFT STATION

1.1 GENERAL

A. Description Of Work

1. This Specification covers the furnishing and installation of sewage lift stations. Work includes but is not limited to earthwork, installation of watertight precast concrete sump basin, basin access cover, submersible sewage pumps, pump guide rail system, pump control system, valves and piping and electrical connections as required. Specific sizes of basins, pumps, and piping shall be as follows or as directed by the Owner.

B. Submittals

1. Product Data: For each type of product indicated.
   a. Pipe and fittings
   b. Check valves
   c. Gate valves
   d. Submersible sewage grinder pumps
   e. Pump motor
   f. Flexible flanged coupling
2. Operation and Maintenance Data: Include pumps, alarms, and motors. Data for submersible sewage grinder pump station data shall include all information on all equipment, alarm panel and controls, pumps and pump performance curves, and station layout.

C. Delivery, Storage, and Handling of Materials

1. Delivery and Storage: Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials in enclosures or under protective covering. Store rubber gaskets not to be installed immediately under cover, out of direct sunlight. Do not store materials directly on the ground. Keep interior of pipes and fittings free of dirt and debris.
2. Handling: Handle pipe, fittings, valves, and other accessories in such manner as to ensure delivery to the trench in sound, undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry pipe to the trench; do not drag it.

1.2 PRODUCTS

A. Precast Concrete Sump Basin(s)

1. Precast Concrete Sump Basin shall be constructed in conformance with Division 02 Section "Underground Ducts And Utility Structures". Basin shall have an integral bottom base section.
2. Joint Sealant: Seal all joints with EZ Stik Butyl Gasket as manufactured by Concrete Products Supply Co., or approved equal. Install in accordance with manufacturer's recommendations.
3. Pipe Opening Seals.
4. Waterproofing: Waterproof interior of concrete sump with one coat of Koppers Coal Tar Bitumastic Black or approved equal. Repair all damaged coating before final backfill. Do not coat cover of basin.
5. Access Hatch - Aluminum Hinged Frame and Cover Model EC-3HD by Syracuse Castings, Cicero, NY (315) 699-2601, or approved equal. Frame and cover shall be heavy duty, rated for H-20 Loadings. Frame shall be angle style frame. Material shall be 6061-T6 aluminum for bars, angles and extrusions. 1/4" diamond plate shall be 5086 aluminum. Unit designed heavy duty, for H-20 wheel loads where not subject to high density traffic. Unit supplied with a heavy duty pneu-spring, for ease of operation when opening cover. Each hatch shall be equipped with a hold open arm. Door shall lock open in the 90 degree position. Hinges shall be of heavy duty design. Material shall be a brass alloy with a 65,000 psi tensile strength. Each hinge shall have a Grade 316 Stainless Steel, 3/8" diameter hinge pin. Exterior of frame, which comes in contact

with concrete shall have one coat black bituminous paint. Unit supplied with a recessed stainless steel slamlock. Angle frame must be completely encased in concrete. Both bearing plates must be fully supported by a bed of concrete.

6. The unit shall be supplied with aluminum safety grate. Safety Grate shall be made of 6061-T6 aluminum with a minimum ultimate strength of 38,000 psi and a minimum yield strength of 35,000 psi as per ASTM B221. Grate design shall use safety factors as defined in the "Specifications for Aluminum Structures", by the Aluminum Association, Inc., 5th edition, DEC. 1986 for "Bridge Type Structures."
   a. Grating shall be designed to withstand a minimum live load of 300 pounds per square foot. Deflection shall not exceed 1/150th of the span.
   b. Grate openings shall be 4" x 4", which will allow for visual inspection of the pit once the access hatch is open.
   c. Each grate shall be provided with a stainless steel, safety check chain. Chain will prevent the grating from falling into the pit.
   d. Welding shall be in accordance with ANSI/AWS D1.2 "Structural Welding Code for Aluminum."

B. Submersible Sewage Pump System
1. Submersible sewage effluent pumps shall be sized as directed by the Owner and specified herein. Pump shall be heavy duty cast iron with stainless steel fasteners. The impeller shall be semi-open, non-clog, engineered plastic capable of passing 3/4" solids. Pump motor shall be oil filled. Pumps shall be equal to SHE-F Series as manufactured by Aurora Pump, or approved equal. Specific pump performance data shall conform to the following:

   1/2 HP Pumps 230 volt/single phase/60 Hz/2" NPT/ 3450 rpm
   40 gpm @ 42 ft. TDH
   50 gpm @ 32 ft. TDH
   60 gpm @ 18 ft. TDH

   1 HP Pumps 230 volt/single phase/60 Hz/2" NPT/3450 rpm
   20 gpm @ 80 ft. TDH
   30 gpm @ 76 ft. TDH
   40 gpm @ 71 ft. TDH
   50 gpm @ 65 ft. TDH

C. Duplex Guide Rail System: Complete package system shall be as manufactured by Moran Manufacturing Inc., or approved equal, as follows.
1. The guide rail assembly shall be constructed of Type 304 stainless steel and shall consist of a minimum of two rails, a bottom base plate, a minimum of one cross brace every 18 inches between the rails and a wall brace, all welded together to provide the maximum structural integrity. The rails shall be round to provide a non-binding surface during installation and removal of the pump. The guide rail assembly shall be installed as a one piece unit and shall be bolted with stainless anchor bolts to the basin bottom and the basin wall a minimum of two places each.
2. The pump bracket assembly shall consist of a top bracket and a bottom bracket. The brackets shall be fabricated of 1/4" steel material and shall be painted with coal tar epoxy paint at such rate as to provide a minimum 10 mil thickness. The top bracket shall be attached to the discharge piping above the pump disconnect and shall be constructed in such a manner that pump cannot be removed from the guide rail assembly except when removing pump out the top of the sump basin. The bottom bracket shall be attached to the pump at the discharge connection and shall guide the pump along the guide rail assembly to ensure proper alignment of the pump.
3. A 3/16" min. (7 x 9) stainless steel lifting cable, 10 ft. longer than the sump depth, shall be furnished for lifting and lowering the pump in the sump basin. The stainless steel lifting cable

shall be of the 18-8 type 302/304 stainless steel and shall have minimum nominal breaking strength of 15 times the weight of the pump. It shall be substantially attached to the top of the pump and shall have a formed loop at the other end.

4. The discharge piping shall include a cast iron ball check valve, with a natural rubber ball and clean out port with plug for easy access, a brass quick disconnect fitting, with an O-ring stem brass gate valve, per pump. All other piping shall be schedule 40 stainless steel.
5. The station shall have a gate valve extension handle per valve which will allow the gate valve to be operated from a maximum of 6" below the basin cover. The handle shall be constructed of a minimum of 3/8" dia. Type 304 stainless steel. The handle shall be held in place by being attached to the gate valve and by the guide rail wall brace.
6. All internal metal parts that are not brass, galvanized steel, or stainless steel shall be painted with coal-tar epoxy paint to resist corrosion, unless otherwise noted.
7. Mercury level control switches shall be provided for lead pump on, lag pump on and high level alarm, pumps off and low level alarm.
8. The mercury switch shall be encapsulated in polyurethane foam for corrosion and shock resistance. Level switches shall be weighted to hold position in the sump. The cord connecting the control shall be No. 16-2, rated for 13 amps, and shall be type C-SJO. To ensure optimum longevity, mercury contacts shall be of the mercury-to-mercury type and encapsulated in a glass tube and shall be rated for 20 amps at 115 VAC.
9. The manufacturer of the lift station shall furnish a limited warranty for 18 months from the date of shipment or 12 months from start-up (whichever occurs first), that all equipment shall be free from defects in design, materials and workmanship. The lift station manufacturer shall furnish replacement parts for any component proven defective whether of his or other manufacturer during the warranty period, excepting only those items which are normally consumed in service, such as (but not limited to) light bulbs, oil, grease, packing, etc.
10. Installation instructions shall be furnished with the station.

D. Control System

1. This system shall be controlled and protected by a packaged system as manufactured by Rombus, or approved equal. The control shall provide automatic start, stop and alternation of 2 pumps, and shall provide an audible alarm as well as visual indication of high level conditions.
2. The control panel shall be pre-wired in a NEMA 3R weatherproof enclosure, and all necessary components including the following: single phase lightning arrestor for protection of the pumps, NEMA rated contractor and thermal magnetic circuit breaker for each pump, a main control/alarm circuit fused disconnect switch, separately fused control and alarm circuits, panel mounted duplex alternating relays, control relays, and terminal blocks for the connection on all external wiring. Provide a 20 amp/115v convenience outlet in each panel on its own GFCI circuit breaker. Multi-colored circuitry is to be used within the control panel to facilitate trouble shooting.
3. Mounted inside the enclosure shall be hand-off-auto switches and run pilot lights for each pump circuit; normal-off-test switch and alarm pilot light for high level alarm; float test toggle switches for each float to override floats to simulate operation; non-resettable elapsed time meters for each pump.
4. Mounted remotely from the Control Panel shall be a 4" 120V alarm bell and a flashing alarm light.

E. System Operation: As the level in the sump rises to the lead pump on level, the pump selected as lead by the alternator will come on line, and will pump the level down to the pump off level. The pump will then turn off, and the alternator will cycle, selecting the other pump as lead for the next cycle. If, with the lead pump running, the level in the tank continues to rise to the lag pump on level, the lag pump will come on line, alarms will sound, and will run with the lead pump until the pumps off level has been reached. The pumps will then be turned off, and the alternator will cycle. If level continues to drop to the low level alarm float, alarm circuits will be activated.

1. Placing the T-O-N switch into the off position will de-energize the alarm bell and flashing light, but the alarm pilot light will remain illuminated until the alarm condition has been cleared. When the alarm pilot light is extinguished, the T-O-N switch may be reset to the normal position, and the alarm will stand ready for the next alarm.

1.3 EXECUTION

A. The Contractor shall excavate the station site to the elevations as required to meet project requirements. Compact the subgrade and install crushed stone.

B. Install lift station in accordance with manufacturer’s recommendations. Perform additional exterior waterproofing as required to repair original coating and to achieve a watertight sump basin. The discharge piping shall be extended and connected to the sewage force mains. Backfill material shall be approved by the Owner. No backfill material shall have any dimension greater than 6". Backfill material within 15" of basin shall not have a dimension greater than 2".

C. The Lift Station control panel shall be mounted to the building nearby and shall have sufficient cord supplied by the Lift Station manufacturer to avoid any splices. All necessary electrical connections between pumps, flow controls and control panel shall be made in accordance with manufacturer's recommendations. No splices shall be made in the basin. Lightning protection shall be provided in the panel.

D. Install pump power conductors in rigid steel conduit between Lift Station and Control Panel.

E. Upon completion, the Lift Station shall be tested to assure there is no leakage and that the pumps, controls and alarm are operating satisfactorily. The Lift Station manufacturer's representative shall be present during initial start up and testing. Three (3) Lift Station operation and maintenance manuals shall be provided.

END OF SECTION 15310a

SECTION 15310b - SEWAGE PUMPS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for sewage pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Submersible effluent pumps.
b. Submersible sewage pumps.
c. Wet-pit-volute sewage pumps.
d. Sewage-pump, reverse-flow assemblies.
e. Sewage-pump basins and basin covers.
f. Progressing-cavity sewage pumps.
g. Packaged, submersible sewage-pump units.
h. Packaged wastewater-pump units.

C. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. UL Compliance: Comply with UL 778 for motor-operated water pumps.

E. Delivery, Storage, And Handling
1. Retain shipping flange protective covers and protective coatings during storage.
2. Protect bearings and couplings against damage.
3. Comply with pump manufacturer's written rigging instructions for handling.

F. Coordination
1. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.2 PRODUCTS

A. Submersible Effluent Pumps
1. Submersible, Fixed-Position, Single-Seal Effluent Pumps:
a. Description: Factory-assembled and -tested effluent-pump unit.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as**

directed, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.

e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.

f. Seal: Mechanical.

g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

1) Motor Housing Fluid: Air **OR** Oil, **as directed**.

h. Controls (rod-and-float type):

1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.

2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.

3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.

4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).

5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

i. Controls (float- and pressure-switch types):

1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.

2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.

3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.

4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Control-Interface Features:

1) Remote Alarm Contacts: For remote alarm interface.

2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:

a) On-off status of pump.

b) Alarm status.

2. Submersible, Fixed-Position, Double-Seal Effluent Pumps:

a. Description: Factory-assembled and -tested effluent-pump unit.

b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.

c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.

d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.

e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.

f. Seals: Mechanical.

g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

1) Motor Housing Fluid: Air **OR** Oil, **as directed**.

i. Controls (rod-and-float type):

1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.

2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.

3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Controls (float- and pressure-switch types):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

k. Control-Interface Features:
1) Remote Alarm Contacts: For remote alarm interface.
2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
a) On-off status of pump.
b) Alarm status.

3. Submersible, Quick-Disconnect, Single-Seal Effluent Pumps:
a. Description: Factory-assembled and -tested effluent-pump unit with guide-rail supports.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.
e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
f. Seal: Mechanical.
g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
h. Controls (rod-and-float type):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
i. Controls (float- and pressure-switch types):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.

4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Control-Interface Features:
1) Remote Alarm Contacts: For remote alarm interface.
2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
a) On-off status of pump.
b) Alarm status.

k. Guide-Rail Supports:
1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

4. Submersible, Quick-Disconnect, Double-Seal Effluent Pumps:
a. Description: Factory-assembled and -tested effluent-pump unit with guide-rail supports.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal effluent pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, closed or semiopen design for clear wastewater, and keyed and secured to shaft.
e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
f. Seals: Mechanical.
g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
1) Motor Housing Fluid: Air **OR** Oil, **as directed**.

i. Controls (rod-and-float type):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Controls (float- and pressure-switch types):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.

3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

k. Control-Interface Features:
1) Remote Alarm Contacts: For remote alarm interface.
2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
a) On-off status of pump.
b) Alarm status.

l. Guide-Rail Supports:
1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

B. Submersible Sewage Pumps
1. Submersible, Fixed-Position, Single-Seal Sewage Pumps:
a. Description: Factory-assembled and -tested sewage-pump unit.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
f. Seal: Mechanical.
g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
h. Controls (rod-and-float type):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
i. Controls (float- and pressure-switch types):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.

2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

j. Control-Interface Features:
1) Remote Alarm Contacts: For remote alarm interface.
2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
a) On-off status of pump.
b) Alarm status.

2. Submersible, Fixed-Position, Double-Seal Sewage Pumps:
a. Description: Factory-assembled and -tested sewage-pump unit.
b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
f. Seals: Mechanical.
g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
i. Controls (rod-and-float type):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
j. Controls (float- and pressure-switch types):
1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
k. Control-Interface Features:
1) Remote Alarm Contacts: For remote alarm interface.
2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
a) On-off status of pump.

b) Alarm status.

3. Submersible, Quick-Disconnect, Single-Seal Sewage Pumps:
   a. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.
   b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
   c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
   d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
   e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
   f. Seal: Mechanical.
   g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
      1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
   h. Controls (rod-and-float type):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
      2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
      5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   i. Controls (float- and pressure-switch types):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
      2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   j. Control-Interface Features:
      1) Remote Alarm Contacts: For remote alarm interface.
      2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
         a) On-off status of pump.
         b) Alarm status.
   k. Guide-Rail Supports:
      1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
      2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
      3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
      4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
      5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
      6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
      7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

4. Submersible, Quick-Disconnect, Double-Seal Sewage Pumps:
   a. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.
   b. Pump type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
   c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
   d. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, and stainless steel, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
   e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
   f. Seals: Mechanical.
   g. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.
   h. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
      1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
   i. Controls (rod-and-float type):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
      2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
      5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   j. Controls (float- and pressure-switch types):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
      2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   k. Control-Interface Features:
      1) Remote Alarm Contacts: For remote alarm interface.
      2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
         a) On-off status of pump.
         b) Alarm status.
   l. Guide-Rail Supports:
      1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
      2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
      3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
      4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
      5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
      6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.

7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

5. Submersible, Quick-Disconnect, Grinder Sewage Pumps:
   a. Description: Factory-assembled and -tested, grinder sewage-pump unit with guide-rail supports.
   b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
   c. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail supports.
   d. Impeller: Bronze or stainless steel; statically and dynamically balanced, with stainless-steel cutter, grinder, or slicer assembly; capable of handling solids; and keyed and secured to shaft.
   e. Pump and Motor Shaft: Stainless steel **OR** steel, **as directed**, with factory-sealed, grease-lubricated ball bearings.
   f. Seal: Mechanical.
   g. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
      1) Motor Housing Fluid: Air **OR** Oil, **as directed**.
   h. Controls (rod-and-float type):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
      2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
      5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   i. Controls (float- and pressure-switch types):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
      2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   j. Control-Interface Features:
      1) Remote Alarm Contacts: For remote alarm interface.
      2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
         a) On-off status of pump.
         b) Alarm status.
   k. Guide-Rail Supports:
      1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
      2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
      3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
      4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
      5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
      6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
      7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

6. Submersible, Quick-Disconnect, Progressing-Cavity, Grinder Sewage Pumps:
   a. Description: Factory-assembled and -tested progressing-cavity, grinder sewage-pump unit with guide-rail supports.
   b. Pump Type: Submersible, progressing-cavity, single-screw rotary, grinder sewage pump as defined in HI 3.1-3.5.
   c. Pump Body: Cast iron.
   d. Pump Bearings: Radial and thrust types.
   e. Pump Shaft: Steel.
   f. Rotor: Stainless steel.
   g. Stator: Buna-N **OR** Natural rubber, **as directed**.
   h. Seal: Packing gland and mechanical types.
   i. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   j. Controls (rod-and-float type):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
      2) Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
      5) High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   k. Controls (float- and pressure-switch types):
      1) Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
      2) Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
      3) Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
      4) High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
   l. Control-Interface Features:
      1) Remote Alarm Contacts: For remote alarm interface.
      2) Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
         a) On-off status of pump.
         b) Alarm status.
   m. Guide-Rail Supports:
      1) Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
      2) Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
      3) Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
      4) Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
      5) Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
      6) Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
      7) Lifting Cable: Stainless steel; attached to pump and cover at manhole.

C. Wet-Pit-Volute Sewage Pumps
   1. Description: Factory-assembled and -tested sewage-pump unit.

2. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with open inlet and threaded or flanged connection for discharge piping.
4. Pump Shaft: Stainless-steel **OR** steel, **as directed**.
5. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron **OR** ASTM A 532/A 532M, abrasion-resistant cast iron **OR** ASTM B 584, cast bronze, **as directed**, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
6. Sleeve Bearings: Bronze. Include oil-lubricated, intermediate sleeve bearings at 48-inch (1200-mm) maximum intervals if basin depth is more than 48 inches (1200 mm), and grease-lubricated, ball-type thrust bearings.
7. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
8. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.1, Class 125, cast-iron flanges and flanged fittings or ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
   a. Modify piping configuration to accommodate reverse-flow assembly.
9. Support Plate: Cast iron or coated steel and strong enough to support pumps, motors, and controls. Refer to Part 1.2 "Sewage-Pump Basins and Basin Covers" Article for requirements.
10. Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.
11. Motor: Single-speed; grease-lubricated ball bearings and mounted on vertical, cast-iron pedestal.
12. Controls (rod-and-float type):
    a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**.
    b. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches (1500 mm).
    e. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
13. Controls (float- and pressure-switch types):
    a. Enclosure: NEMA 250, Type 1 **OR** Type 4X, **as directed**; pedestal-mounted **OR** wall-mounted, **as directed**.
    b. Switch Type: Mechanical-float **OR** Mercury-float **OR** Pressure, **as directed**, type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
    c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
    d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
14. Control-Interface Features:
    a. Remote Alarm Contacts: For remote alarm interface.
    b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
       1) On-off status of pump.
       2) Alarm status.

D. Sewage-Pump, Reverse-Flow Assemblies
1. Description: Factory-fabricated, sewage pump reverse-flow assembly for factory or field assembly and installation in sewage pump basin. Include the following corrosion-resistant-metal components:
   a. Inlet Fitting: One combination inlet-overflow strainer fitting.
   b. Valves: Two shutoff valves and two check valves.
   c. Strainers: Two strainer housings with reverse-flow, self-flushing strainers.
   d. Pipe and Fittings: Size and configuration required to connect to sewage pumps and piping.

E. Sewage-Pump Basins And Basin Covers

1. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
   a. Material: Cast iron **OR** Fiberglass **OR** Polyethylene, **as directed**.
   b. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports if used, and accessories.
   c. Anchor Flange: Same material as or compatible with basin sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
2. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
   a. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

F. Progressing-Cavity Sewage Pumps
1. Description: Factory-assembled and -tested progressing-cavity, single-screw rotary pump as defined in HI 3.1-3.5.
2. Pump Body: Cast iron with feet for base or floor installation.
3. Pump Bearings: Radial and thrust types.
4. Pump Shaft: Steel.
5. Rotor: Chrome-plated steel.
6. Stator: Buna-N **OR** Natural rubber, **as directed**.
7. Seals: Packing gland and mechanical types.
8. Coupling: Flexible.
9. Motor: Single-speed; grease-lubricated ball bearings.

G. Packaged, Submersible Sewage-Pump Units
1. Packaged, Submersible, Grinder, Sewage-Pump Units:
   a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, grinder, sewage-pump unit.
   b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
   c. Pump Casing: Cast iron.
   d. Impeller: Stainless-steel grinder, cutter, or slicer type with shredding ring.
   e. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
   f. Control (for simplex pump unit): Manufacturer's standard panel for one pump.
   g. Controls (for duplex pump unit): Automatic, with mechanical- or mercury-float switches and alternator.
   h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
   i. Basin: Watertight plastic, **as directed**, and of size required for pumps, with inlet pipe connection and gastight cover with pump discharge and vent connections.
2. Packaged, Submersible, Nonclog, Sewage-Pump Units:
   a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, sewage-pump unit.
   b. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
   c. Pump Casing: Cast iron.
   d. Impeller: Brass or cast iron; statically and dynamically balanced, non-clog design, and capable of handling 2-inch (50-mm) diameter solids.
   e. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.

f. Control (for simplex pump units): Manufacturer's standard panel for one pump.
g. Controls (for duplex pump unit): Automatic, with mechanical- or mercury-float switches and alternator.
h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
i. Basin: Watertight plastic, **as directed**, and of size required for pumps, with inlet pipe connection and gastight cover with pump discharge and vent connections.

H. Packaged Wastewater-Pump Units
1. Packaged, Wet-Pit-Volute, Wastewater-Pump Units:
a. Description: Factory-assembled and -tested, automatic-operation, basin-mounted, effluent-pump unit.
b. Pump Type: Wet-pit-volute, single-stage, separately-coupled, overhung-impeller centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Body and Impeller: Corrosion-resistant materials.
d. Motor: With built-in overload protection and mounted vertically on basin cover.
e. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm) and with grounding plug and cable-sealing assembly for connection at pump.
f. Control: Float switch.
g. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
h. Basin: Watertight, aluminum, plastic, or coated steel with inlet pipe connection and gastight cover with vent and pump discharge connections.
2. Packaged, Submersible Wastewater-Pump Units:
a. Description: Factory-assembled and -tested, automatic-operation, effluent-pump unit with basin.
b. Pump Type: Submersible, end-suction, single-stage, overhung-impeller, centrifugal pump as defined in HI 1.1-1.2 and HI 1.3.
c. Pump Body and Impeller: Corrosion-resistant materials.
d. Pump Seals: Mechanical.
e. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection.
f. Power Cord: Three-conductor, waterproof cable of length required but not less than 72 inches (1830 mm) and with grounding plug and cable-sealing assembly for connection at pump.
g. Control: Float switch.
h. Pump Discharge Piping: Factory or field fabricated, galvanized, ASTM A 53/A 53M, Schedule 40, steel pipe with ASME B16.4, Class 125, gray iron threaded fittings, **as directed**.
i. Basin: Watertight plastic with inlet pipe connection and gastight cover with vent and pump discharge connections.

I. Motors
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Plumbing Equipment".
a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.
2. Motors for submersible pumps shall be hermetically sealed.

1.3 EXECUTION

A. Earthwork
1. Excavation and filling are specified in Division 02 Section "Earthwork".

B. Examination
1. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

C. Installation
1. Pump Installation Standards:
   a. Comply with HI 1.4 for installation of centrifugal pumps.
   b. Comply with HI 3.1-3.5 for installation of progressing-cavity sewage pumps.
2. Equipment Mounting (for equipment supported on slabs-on-grade): Install progressing-cavity sewage pumps on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install progressing-cavity sewage pumps using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
4. Equipment Mounting: Install progressing-cavity sewage pumps on vibration isolation equipment base. Comply with requirements specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
5. Wiring Method (for pumps with wall-mounted controls): Comply with requirements in Division 16 Section "Conductors And Cables".
6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Connections
1. Comply with requirements for piping specified in Division 15 Section "Sanitary Waste And Vent Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.

E. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Perform each visual and mechanical inspection.
   b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Pumps and controls will be considered defective if they do not pass tests and inspections.

4. Prepare test and inspection reports.

F. Startup Service
1. Engage a factory-authorized service representative to perform **OR** Perform, **as directed**, startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.

G. Adjusting
1. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
2. Adjust control set points.

H. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION 15310b

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Task	Specification	Specification Description
15310	01352	No Specification Required

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SECTION 15320 - INTERCEPTORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for interceptors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Grease interceptors.
b. Oil interceptors.
c. Sand interceptors.

C. Definitions
1. FRP: Fiberglass-reinforced plastic.
2. PP: Polypropylene plastic.

D. Submittals
1. Product Data: For each type of metal and plastic interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
2. Shop Drawings: For each type and size of precast-concrete interceptor indicated.
a. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.
3. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, based on input from Installers of the items involved:
a. Interceptors.
b. Piping connections. Include size, location, and elevation of each.
c. Interface with underground structures and utility services.

E. Project Conditions
1. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:
a. Notify the Owner no fewer than seven days in advance of proposed interruption of service.
b. Do not proceed with interruption of sewer services without the Owner's written permission.

1.2 PRODUCTS

A. Grease Interceptors
1. Grease Interceptors: Precast concrete complying with ASTM C 913.
a. Include rubber-gasketed joints, vent connections (if required), manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow, unless directed otherwise.
b. Structural Design Loads:
1) Light-Traffic Load: Comply with ASTM C 890, A-8 (ASSHTO HS10-44).
2) Medium-Traffic Load: Comply with ASTM C 890, A-12 (ASSHTO HS15-44).
3) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
4) Walkway Load: Comply with ASTM C 890, A-03.

c. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into interceptor walls, for each pipe connection.

d. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of interceptor to finished grade is less than 60 inches (1500 mm).

e. Grade Rings (if required): Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.

f. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.

1) Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.

2) Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.

3) Include indented top design with lettering cast into cover, using wording equivalent to "INTERCEPTOR," or “GREASE INTERCEPTOR,” or “SANITARY SEWER."

B. Oil Interceptors

1. Oil Interceptors: Precast concrete comply with ASTM C 913.

a. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.

b. Structural Design Loads:

1) Light-Traffic Load: Comply with ASTM C 890, A-8 (ASSHTO HS10-44).

2) Medium-Traffic Load: Comply with ASTM C 890, A-12 (ASSHTO HS15-44).

3) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).

4) Walkway Load: Comply with ASTM C 890, A-03.

c. Resilient Pipe Connectors (if required): ASTM C 923 (ASTM C 923M), cast or fitted into interceptor walls, for each pipe connection.

d. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**,, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of interceptor to finished grade is less than 60 inches (1500 mm).

e. Grade Rings (if required): Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.

f. Manhole Frames and Covers: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.

1) Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.

2) Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.

3) Include indented top design with lettering cast into cover, using wording equivalent to "INTERCEPTOR," or “OIL INTERCEPTOR,” or “SANITARY SEWER."

g. Waste-oil storage tank and piping are specified in Division 15 Section "Facility Fuel-oil Piping".

2. Oil Interceptors: Factory-fabricated, cast-iron or steel body; with removable sediment bucket or strainer, baffles, vents, and flow-control fitting on inlet.

a. Inlet, Outlet, Vent, and Waste-Oil Outlet Piping Connections: Hub, hubless, or threaded, unless otherwise indicated.

b. Extension (if required): Cast-iron or steel shroud, full size of interceptor, extending from top of interceptor to grade.

c. Cover: Cast iron or steel, with steel reinforcement to provide ASTM C 890, A-03, walkway load, **as directed**.
d. Comply with requirements in Division 15 Section "Facility Fuel-oil Piping" for waste-oil storage tank and piping

3. Oil Interceptors: Plastic body; with removable sediment bucket or strainer, baffles, vents, and flow-control fitting on inlet.
   a. Inlet, Outlet, Vent, and Waste-Oil Outlet Piping Connections: Hub, hubless, or threaded, unless otherwise indicated.
   b. Extension (if required): Plastic shroud, full size of interceptor, extending from top of interceptor to grade.
   c. Cover: Plastic with steel reinforcement to provide ASTM C 890, A-03, walkway load, as **directed**.
   d. Waste-oil storage tank and piping are specified in Division 15 Section "Facility Fuel-oil Piping".

C. Sand Interceptors
1. Description: Factory-fabricated, cast-iron or steel body and inlet grate; with settlement chamber and removable basket or strainer.
2. Outlet Piping Connection: Hub, hubless, or threaded, unless otherwise indicated.
3. Grate: Cast iron or steel with reinforcement to provide ASTM C 890, A-03, walkway load, **as directed**.

D. Precast-Concrete Manhole Risers
1. Precast-Concrete Manhole Risers: ASTM C 478 (ASTM C 478M) **OR** ASTM C 913, **as directed**, with rubber-gasket joints.
   a. Structural Design Loads:
      1) Light-Traffic Load: Comply with ASTM C 890, A-8 (ASSHTO HS10-44).
      2) Medium-Traffic Load: Comply with ASTM C 890, A-12 (ASSHTO HS15-44).
      3) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
      4) Walkway Load: Comply with ASTM C 890, A-03.
   b. Length: From top of underground concrete structure to grade.
   c. Riser Sections: 3-inch (75-mm) minimum thickness and 36-inch (915-mm) diameter.
   d. Top Section: Eccentric cone, unless otherwise indicated. Include top of cone to match grade ring size.
   e. Gaskets: ASTM C 443 (ASTM C 443M), rubber.
   f. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps, FRP ladder, or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals.
2. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, diameter matching manhole frame and cover, and height as required to adjust the manhole frame and cover to indicated elevation and slope.
3. Manhole Frames and Covers (if required): Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (100-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover.
   a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
   b. Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.
   c. Include indented top design with lettering cast into cover, using wording equivalent to the following:
      1) Grease Interceptors in Sanitary Sewerage System: "INTERCEPTOR" **OR** “GREASE INTERCEPTOR” **OR** “SANITARY SEWER", **as directed.**
      2) Oil Interceptors in Sanitary Sewerage System: "INTERCEPTOR” **OR** “OIL INTERCEPTOR” **OR** “SANITARY SEWER", **as directed**.

1.3 EXECUTION

A. Earthwork
   1. Excavating, trenching, and backfilling are specified in Division 02 Section "Earthwork".

B. Installation
   1. Install precast-concrete interceptors according to ASTM C 891. Set level and plumb.
   2. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.
   3. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches (75 mm) above finish surface elsewhere, unless otherwise indicated.
   4. Set tops of grating frames and grates flush with finished surface.
   5. Set metal and plastic interceptors level and plumb.
   6. Set tops of metal interceptor covers flush with finished surface in pavements. Set tops 3 inches (75 mm) above finish surface elsewhere, unless otherwise indicated.
   7. Install piping and oil storage tanks according to Division 15 Section "Facility Fuel-oil Piping".

C. Connections
   1. Piping installation requirements are specified in other Division 02. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Make piping connections between interceptors and piping systems.

D. Identification
   1. Identification materials and installation are specified in Division 02 Section "Earthwork". Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
      a. Use warning tapes or detectable warning tape over ferrous piping.
      b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

END OF SECTION 15320

Task	Specification	Specification Description
15322	15320	Interceptors
15325	15320	Interceptors

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SECTION 15341 - CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for chemical-waste systems for laboratory and healthcare facilities. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

C. Summary
1. Section Includes:
a. Single-wall piping.
b. Double-containment piping.
c. Field-fabrication containment piping.
d. Piping specialties.
e. Neutralization tanks.
f. Neutralization systems.
g. Manholes.
h. Leak-detection systems.

D. Definitions
1. CR: Chlorosulfonated polyethylene synthetic rubber.
2. FPM: Vinylidene fluoride-hexafluoro propylene copolymer rubber.

E. Performance Requirements
1. Single-Wall Piping Pressure Rating: 10 feet head of water (30 kPa).
2. Double-Containment Piping Pressure Rating:
a. Carrier Piping: 5-psig (34.5-kPa) air test pressure.
b. Containment Piping: 5-psig (34.5-kPa) air test pressure.
3. Field-Fabrication Containment-Piping Pressure Rating: 5-psig (34.5-kPa) air test pressure.
4. Delegated Design: Design seismic restraints for aboveground piping, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

F. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
3. Shop Drawings: For neutralization system and leak-detection system. Include plans, elevations, sections, details, and attachments to other work.
a. Detail neutralization-system assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Detail leak-detection-system assemblies and indicate required clearances, method of field assembly, components, and location and size of each field connection.
c. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
5. Profile Drawings for Outdoor Underground Piping: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not

less than 1 inch equals 5 feet (1:50). Indicate underground structures and pipes. Show types, sizes, materials, and elevations of other utilities crossing system piping.

6. Field quality-control test reports.
7. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks, neutralization systems, and leak-detection systems to include in emergency, operation, and maintenance manuals.

G. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."

H. Delivery, Storage, And Handling
1. Deliver and store piping and specialties with sealing plugs in ends or with end protection.
2. Do not store plastic pipe or fittings in direct sunlight.
3. Protect pipe, fittings, and seals from dirt and damage.

I. Project Conditions
1. Interruption of Existing Chemical-Waste Service: Do not interrupt chemical-waste service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary chemical-waste service according to requirements indicated:
   a. Notify the Owner no fewer than two days in advance of proposed interruption of chemical-waste service.
   b. Do not proceed with interruption of chemical-waste service without the Owner's written permission.

1.2 PRODUCTS

A. Single-Wall Pipe And Fittings
1. PE Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
   a. Pipe: ASTM F 1412, Schedule 40.
   b. Fittings: ASTM F 1412, Schedule 40, socket-fusion, drainage pattern complying with ASTM D 3311.
2. PP Drainage Pipe and Fittings: ASTM F 1412, pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions, from PP resin with fire-retardant additive complying with ASTM D 4101; with fusion **OR** fusion- and mechanical **OR** mechanical, **as directed**,-joint ends.
   a. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
3. PVC Drainage Pipe and Fittings: ASTM D 2665, pipe and drainage-pattern fittings.
4. PVDF Drainage Pipe and Fittings: ASTM F 1673, Schedule 40, pipe and drainage-pattern fittings. Include fittings with fusion **OR** fusion- and mechanical **OR** mechanical, **as directed**,-joint ends.
5. Fiberglass Pipe and Fittings, Centrifugally Cast: ASTM D 2997, Type II, Grade 1 **OR** Grade 2, **as directed**, Class A **OR** Class B **OR** Class C, **as directed**, RTRP pipe; with ASTM D 5685, Type 4, RTRF fittings matching pipe; and adhesive-bonding **OR** butt-and-wrap-joint, **as directed**, materials. Include wall thickness that will provide 160-psig (1105-kPa) minimum, sustained water test pressure rating.
6. Fiberglass Pipe and Fittings, Filament Wound: ASTM D 2996, Type I, Grade 1 **OR** Grade 2, **as directed**, Class A **OR** Class B **OR** Class C **OR** Class E **OR** Class F, **as directed**, RTRP pipe; ASTM D 5685, Type 1, RTRF fittings matching pipe; and adhesive-bonding **OR** butt-and-wrap-joint, **as directed**, materials. Include wall thickness that will provide 160-psig (1105-kPa) minimum, sustained water test pressure rating.

7. High-Silicon-Iron, Hub-and-Plain-End Pipe and Fittings: ASTM A 861, pipe and drainage-pattern fittings; acid-resistant packing; and lead calking materials.
8. High-Silicon-Iron, Mechanical-Joint Pipe and Fittings: ASTM A 861, pipe and drainage-pattern fittings; and stainless-steel clamps with TFE inner sleeve and CR outer sleeve.
9. Stainless-Steel Drainage Pipe and Fittings: ASME A112.3.1, ASTM A 666, Type 316L, stainless-steel pipe and drainage-pattern fittings; with socket and spigot ends for gasket joints; and having piping manufacturer's FPM lip-seal rubber gaskets shaped to fit socket groove, with plastic backup ring.
10. Borosilicate Glass Pipe and Fittings: ASTM C 1053, pipe and drainage-pattern fittings; with manufacturer's standard couplings.
    a. Covering: Factory-applied polystyrene for pipe installed underground.
11. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

B. Double-Containment Pipe And Fittings
1. Description: Factory-fabricated, double-wall pipe and fittings. Sizes indicate carrier-pipe size; with carrier (inner) pipe and fittings; annular-space, carrier-pipe supports; containment (outer) pipe and fittings; and joining materials and fasteners. Include manufacturer's standard piping materials according to the following:
    a. PE, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
        1) Carrier and Containment Pipes: ASTM F 1412, Schedule 40.
        2) Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311.
    b. PP, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4101, PP resin.
        1) Carrier and Containment Pipes: ASTM F 1412, Schedule 40.
        2) Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311.
    c. PP/PVC, Double-Containment Drainage Pipe and Fittings:
        1) PP Carrier Pipe: ASTM F 1412, Schedule 40; made of ASTM D 4101, PP resin.
        2) PP Carrier-Pipe Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311; made of ASTM D 4101, PP resin.
        3) PVC Containment Pipe: ASTM D 2665, PVC pipe.
        4) PVC Containment Pipe Fittings: ASTM D 2665, PVC drainage pattern.
    d. PVDF, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 3222, PVDF resin.
        1) Carrier and Containment Pipes: ASTM F 1673, Schedule 40.
        2) Fittings: ASTM F 1673, Schedule 40 drainage pattern complying with ASTM D 3311.
    e. PVDF/PVC, Double-Containment Drainage Pipe and Fittings:
        1) PVDF Carrier Pipe: ASTM F 1673, Schedule 40; made of ASTM D 3222, PVDF resin.
        2) PVDF Carrier-Pipe Fittings: ASTM F 1673, Schedule 40 drainage pattern complying with ASTM D 3311; made of ASTM D 3222, PVDF resin.
        3) PVC Containment Pipe: ASTM D 2665, PVC pipe.
        4) PVC Containment Pipe Fittings: ASTM D 2665, PVC drainage pattern.
2. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

C. Field-Fabrication Containment Piping
1. Description: Containment split pipe and split fittings with carrier-pipe centralizers. Include manufacturer's fastening devices and materials.
    a. Material: HDPE **OR** PP **OR** Yellow PVC **OR** Clear PVC, **as directed**, pipe and fittings.
    b. Fastening System: FPM gaskets, clamps, and pins.

c. Material: Clear PVC pipe and fittings with adhesive channels, for use with drainage-pattern carrier piping.
d. Fastening System: Adhesive.

D. Joining Materials
1. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.
2. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.
3. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.
4. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Fiberglass-Pipe Adhesive: As furnished or recommended by pipe manufacturer.
   a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

E. Piping Specialties
1. Plastic Dilution Traps:
   a. Material: Corrosion-resistant PP, with removable base.
   b. End Connections: Mechanical joint.
   c. Dilution Tanks: 1-gal. (3.8-L) capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 (DN 40) top inlets and one NPS 1-1/2 (DN 40) side outlet.
   d. Small Dilution Jars: 1-pint (0.5-L) capacity, with clear base unless colored base is indicated; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
   e. Large Dilution Jars: 1-quart (1-L) capacity; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
2. High-Silicon-Iron Dilution Traps:
   a. Standard: ASTM A 861.
   b. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50) as required for fixture and waste.
   c. End Connections: Mechanical.
3. Glass, Drain-Line, Interceptor Traps:
   a. Standard: ASTM C 1053.
   b. Type: Drum trap.
   c. Size: NPS 1-1/2 (DN 40), NPS 2 by NPS 1-1/2 (DN 50 by DN 40), or NPS 2 (DN 50), as required to match connecting piping.
4. Corrosion-Resistant Traps:
   a. Type: P-trap or drum trap.
   b. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50), as required to match connected piping.
   c. High-Silicon Iron: ASTM A 861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
   d. PP: ASTM D 4101, with mechanical-joint pipe connections.
   e. PVDF: ASTM D 3222, with mechanical-joint pipe connections.
   f. Glass: ASTM C 1053, with coupling pipe connections.
5. High-Silicon-Iron Floor Drains:
   a. Standard: ASTM A 861.
   b. Body: With integral flashing flange and weep holes; and with flashing ring and stainless-steel strip, sediment basin and funnel attachment, **as directed**.

c. Top: 8-3/4-inch (222-mm) diameter with grate.
d. Size: NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.

6. Stainless-Steel Floor Drains:
   a. Standard: ASME A112.3.1, ASTM A 666, Type 316L.
   b. Body: With 8.5-by-8.5-inch (215-by-215-mm) **OR** 12.4-by-12.4-inch (315-by-315-mm), **as directed**, top with grate.
   c. Outlet: Bottom, of size indicated.
7. PP Floor Drains:
   a. Body: With 7- to 9-inch (178- to 230-mm) top diameter, with flashing flange and weep holes; and with flashing clamp, basket strainer, funnel attachment, and trap-primer connection, **as directed**.
   b. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.
8. High-Silicon-Iron Cleanouts:
   a. Standard: ASTM A 861, fitting with PTFE gasket and closure plug, of design appropriate for piping application.
9. Stainless-Steel Cleanouts:
   a. Standard: ASME A112.3.1, ASTM A 666, Type 316L, stainless steel.
   b. Aboveground Piping: Cleanout tee of size matching piping.
   c. Underground and Underslab Piping: Floor access cleanout of size matching piping.
10. High-Silicon-Iron Backwater Valves:
    a. Standard: ASTM A 861.
    b. Body: Hub-and-plain end with swing-check valve; and with high-silicon-iron pipe extension of length to reach floor surface, and high-silicon-iron closure plug, **as directed**.
11. Plastic Backwater Valves:
    a. Description: Full-port NPS 3 (DN 80) check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.
       1) Exception: PVC material for use with PVC piping systems.
12. High-Silicon-Iron Sink Outlets:
    a. Standard: ASTM A 861, high-silicon iron, NPS 1-1/2 (DN 40), with clamping device and 4-, 6-, or 8-inch- (100-, 150-, or 200-mm-) high overflow fitting, as indicated.
13. PP Sink Outlets:
    a. Description: NPS 1-1/2 (DN 40), with clamping device, stopper, and 7-inch- (178-mm-) high overflow fitting.
14. Glass Sink Outlets:
    a. Standard: ASTM C 1053, components for field assembly, NPS 1-1/2 (DN 40); with sink assembly of outlet, strainer, gasket, and locknut; overflow fitting of length indicated; and tailpiece assembly of borosilicate glass and locknut.

F. Neutralization Tanks
1. Plastic Neutralization Tanks:
   a. Description: Corrosion-resistant plastic materials; with removable, gastight cover; interior, sidewall, dip-tube inlet; outlet; vent; and threaded or flanged, sidewall pipe connections.
      1) Material: HDPE **OR** ASTM D 4101, PP, **as directed**.
      2) Tank Capacity: as directed by the Owner.
      3) Dip Tube: On outlet pipe instead of inlet pipe.
      4) Extension: HDPE, PE, or PP.
      5) Traffic Cover: Light-duty **OR** Heavy-duty pedestrian or light-duty vehicular, steel plate over, **as directed**, plastic, bolted.
      6) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
         OR

Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

2. Ceramic Neutralization Tanks:
   a. Description: Corrosion-resistant, cast-ceramic shell; with removable, reinforced-plastic, gastight cover; inlet; interior, sidewall, dip-tube outlet; vent; and bell, sidewall pipe connections.
      1) Extension: Ceramic, of size and length indicated, and with cast-iron manhole frame and cover.
         OR
         Extension: Steel with protective coating, 28-inch (710-mm) diameter, and cast-iron manhole frame and cover.
      2) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
         OR
         Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
3. Collection Tanks: Corrosion-resistant, cast-ceramic shell. Include removable, reinforced-plastic, gastight cover; inlet; vent; and bell, sidewall pipe connections.
   a. Extension: Ceramic **OR** Steel with protective coating, **as directed**, 28-inch (710-mm) minimum diameter, and cast-iron manhole frame and cover.

G. Neutralization Systems
1. Plastic-Tank Neutralization Systems:
   a. Description: Automatic system for neutralizing chemical waste.
      1) Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
      2) Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, but not less than the following:
         a) Power light and on/off switch.
         b) pH analyzer with meter and high- and low-pH indicators.
         c) Low caustic- and acid-solution level indicators.
         d) Alarm horn with silencer and reset switch.
         e) Agitator running light with on/off switch.
         f) Running lights with on/off switches for caustic- and acid-solution pumps.
      3) Strip chart recorder with capacity for 30-day record.
      4) Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
      5) Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.
      6) Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.
         a) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
            OR
            Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
      7) Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.

a) Material: HDPE **OR** ASTM D 4101, PP, **as directed**.
b) pH Probe: Type and length suitable for mixing-tank size.
c) Agitator: Electric, with stainless-steel shaft and propeller.

8) Caustic-Solution Storage Tank: PP.
a) Caustic Chemical: Sodium hydroxide solution.

9) Acid Storage Tank: PP.
a) Acid Chemical: Sulfuric acid solution.

10) Metering Pumps: Types suitable for neutralizing solutions.

11) Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.
a) pH probe: Type and length suitable for sampling-tank size.

2. Ceramic-Tank Neutralization Systems:

a. Description: Automatic system for neutralizing chemical waste.

1) Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.

2) Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, including the following:
a) Power light and on/off switch.
b) pH analyzer with meter and high- and low-pH indicators.
c) Low caustic- and acid-solution level indicators.
d) Alarm horn with silencer and reset switch.
e) Agitator running light with on/off switch.
f) Running lights with on/off switches for caustic- and acid-solution pumps.

3) Strip chart recorder with capacity for 30-day record.

4) Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.

5) Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.

6) Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.
a) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
OR
Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

7) Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.
a) Material: Clay, vitrified into ceramic unit.
b) pH Probe: Type and length suitable for mixing tank size.
c) Agitator: Electric, with stainless-steel shaft and propeller.

8) Caustic-Solution Storage Tank: PP.
a) Caustic Chemical: Sodium hydroxide solution.

9) Acid Storage Tank: PP.
a) Acid Chemical: Sulfuric acid solution.

10) Metering Pumps: Types suitable for neutralizing solutions.

11) Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.
a) pH probe: Type and length suitable for sampling-tank size.

H. Manholes

1. Description: ASTM F 1759, fabricated from PE components. Include bottom, sidewalls, and top sections; corrosion-resistant, manhole frame and cover; fusion or other watertight joints; and design to prohibit flotation.
   a. Construction: Single wall **OR** Double wall with interstitial space, **as directed**.
   b. Bottom: Channeled.
   c. Connections: Inlets and outlet matching or suitable for piping.
   d. Steps: Manufacturer's standard, fusion welded to sidewall. Omit steps for manholes less than 60 inches (1500 mm) deep.
   e. Top: Include 24-inch- (610-mm-) nominal-diameter frame and cover.

I. Leak-Detection Systems
1. Leak-Detection Systems:
   a. Description: Cable leak-detection system capable of detecting and annunciating fluid leaks; with controls, panel, wiring, cable sensors, probes if required, and piping.
      1) Annunciator Panel: Enclosure with visual and audible alarms and leak location indicator.
      2) Sensors: Electric cable, suitable for insertion into double-containment piping annular space, with capability of detecting fluid leaks and signaling locations of leaks.

J. Sleeves
1. Cast-Iron Wall Pipes: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
2. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
3. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
4. Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, plain ends.
5. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   a. Underdeck Clamp: Clamping ring with set screws.

K. Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
   a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
   b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.

L. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
3. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
4. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
5. One-Piece, Floor-Plate Escutcheons: Cast iron.
6. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

M. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
c. Packaging: Premixed and factory packaged.

1.3 EXECUTION

A. Earthwork
1. Comply with requirements in Division 02 Section "Earthwork" for excavating, trenching, and backfilling.

B. Concrete Bases
1. Anchor neutralization tanks and neutralization system tanks to concrete bases.
a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 19-inch (480-mm) centers around full perimeter of base.
b. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
d. Install anchor bolts to elevations required for proper attachment to supported equipment.
e. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
f. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
g. Comply with requirements in Division 02 for cast-in-place concrete materials and placement.

C. Piping Installation
1. Chemical-Waste Sewerage Outside the Building:
a. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
b. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
c. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
d. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
e. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.
f. Install drainage piping pitched down in direction of flow, at minimum slope of 1 **OR** 2, **as directed**, percent, unless otherwise indicated.
g. Install drainage piping with 36-inch (915-mm) **OR** 48-inch (1220-mm) **OR** 60-inch (1524-mm) **OR** 72-inch (1830-mm), **as directed**, minimum cover.
h. Install PE drainage piping according to ASTM D 2321 and ASTM F 1668.
i. Install PVC drainage piping according to ASTM D 2321 and ASTM F 1668.
j. Install PVDF drainage piping according to ASTM D 2321 and ASTM F 1668.
k. Install fiberglass piping according to ASTM D 3839 and ASTM F 1668.
l. Install field-fabrication containment piping over new and existing carrier piping. Use containment piping manufacturer's fastening system.

m. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

2. Chemical-Waste Piping Inside the Building:
   a. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
   b. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
   c. Flanges may be used on aboveground piping unless otherwise indicated.
   d. Install underground fiberglass piping according to ASTM D 3839.
   e. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
   f. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
   g. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
   h. Install piping at indicated slopes.
   i. Install piping free of sags and bends.
   j. Install fittings for changes in direction and branch connections.
   k. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
      1) New Piping:
         a) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
         b) Insulated Piping: One-piece, stamped-steel type with spring clips.
         c) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
         d) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge **OR** One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
         e) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
         f) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
         g) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
      2) Existing Piping:
         a) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
         b) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
         c) Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
         d) Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
         e) Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
         f) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
   l. Sleeves are not required for core-drilled holes.
   m. Permanent sleeves are not required for holes formed by removable PE sleeves.
   n. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

OR

Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1) Cut sleeves to length for mounting flush with both surfaces.
   a) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
2) Install sleeves in new walls and slabs as new walls and slabs are constructed.
3) Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a) PVC **OR** Steel, **as directed**, Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum board partitions.
   c) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
   d) Seal space outside of sleeve fittings with grout.
4) Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

o. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1) Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
   2) Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
   3) Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

p. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
   1) Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Through-penetration Firestop Systems" for materials.

r. Verify final equipment locations for roughing-in.

D. Piping Specialty Installation
   1. Embed floor drains in 4-inch (100-mm) minimum depth of concrete around bottom and sides. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for concrete.
   2. Fasten grates to drains if indicated.
   3. Set floor drains with tops flush with pavement surface.
   4. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

a. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade. Set cleanout plugs in concrete pavement with tops flush with pavement surface. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for formwork, reinforcement, and concrete requirements.

5. Install backwater valves in horizontal position. Include riser to cleanout at grade.

E. Joint Construction

1. Chemical-Waste Sewerage Outside the Building:
   a. Plastic-Piping, Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
   b. Make fiberglass-piping bonded joints according to ASTM D 3839.
   c. Make fiberglass butt-and-wrap joints according to ASTM D 3839.
   d. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.
   e. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
   f. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
   g. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
2. Chemical-Waste Piping Inside the Building:
   a. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
   b. Fiberglass-Piping Joints: Make joints with piping manufacturer's bonded adhesive.
   c. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.
   d. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
   e. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
   f. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.

F. Hanger And Support Installation

1. Pipe sizes in this article refer to aboveground, single-wall piping and carrier piping of containment piping, **as directed**.
2. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
3. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices. Install the following:
   a. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
   b. Individual, Straight, Horizontal Piping Runs:
      1) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
      2) Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
      3) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
   c. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
   d. Base of Vertical Piping: MSS Type 52, spring hangers.
4. Comply with requirements in Division 15 Section "Hangers And Supports For Plumbing Piping And Equipment" for installation of supports.
5. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting and coupling.
6. Support vertical piping and tubing at base and at each floor.
7. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch (10 mm).
8. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
   a. NPS 2 (DN 50): 33 inches (840 mm) with 3/8-inch (10-mm) rod.
   b. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.

c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
d. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
e. NPS 8 (DN 200): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.

9. Install supports for vertical PP piping every 72 inches (1830 mm).
10. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1-1/4 (DN 32): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
    b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 42 inches (1067 mm) with 3/8-inch (10-mm) rod.
    c. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
    d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
    e. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
    f. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.
11. Install supports for vertical PVC piping every 48 inches (1220 mm).
12. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:
    a. All Sizes: Install continuous support for piping with liquid waste at temperatures above 140 deg F (60 deg C).
    b. NPS 1/2 (DN 15) and Smaller: 30 inches (760 mm) with 3/8-inch (10-mm) rod.
    c. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
    d. NPS 2 (DN 50): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
    e. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
    f. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
    g. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
13. Install supports for vertical PVDF piping NPS 1-1/2 (DN 40) every 48 inches (1220 mm) and NPS 2 (DN 50) and larger every 72 inches (1830 mm).
14. Install vinyl-coated hangers for fiberglass piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 2 (DN 50) and Smaller: 10 feet (3 m) with 3/8-inch (10-mm) rod.
    b. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.
    c. NPS 4 and NPS 5 (DN 100 and DN 125): 10 feet (3 m) with 5/8-inch (16-mm) rod.
    d. NPS 6 (DN 150): 10 feet (3 m) with 3/4-inch (19-mm) rod.
    e. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.6 m) with 7/8-inch (22-mm) rod.
15. Install supports for vertical fiberglass piping every 12 feet (3.6 m).
16. Install hangers for stainless-steel drainage piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
    b. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
    c. NPS 3 (DN 80): 12 feet (3.6 m) with 1/2-inch (13-mm) rod.
    d. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.6 m) with 5/8-inch (16-mm) rod.
    e. NPS 6 (DN 150): 12 feet (3.6 m) with 3/4-inch (19-mm) rod.
17. Install supports for vertical stainless-steel drainage piping every 15 feet (4.5 m).
18. Install hangers for high-silicon-iron piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1520 mm) with 3/8-inch (10-mm) rod.
    b. NPS 3 (DN 80): 60 inches (1520 mm) with 1/2-inch (13-mm) rod.
    c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1520 mm) with 5/8-inch (16-mm) rod.
    d. NPS 6 (DN 150): 60 inches (1520 mm) with 3/4-inch (19-mm) rod.
    e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1520 mm) with 7/8-inch (22-mm) rod.
    f. NPS 15 (DN 375): 60 inches (1520 mm) with 1-inch (25-mm) rod.
    g. Spacing for horizontal pipe in 84-inch (2134-mm) lengths may be increased to 84 inches (2134 mm). Spacing for fittings is limited to 60 inches (1520 mm).

19. Install supports for vertical high-silicon-iron piping every 15 feet (4.5 m).
20. Install vinyl-coated hangers for glass piping with the following maximum horizontal spacing and minimum rod diameters:
    a. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1830 mm) with 3/8-inch (10-mm) rod.
    b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2440 mm) with 3/8-inch (10-mm) rod.
    c. NPS 3 (DN 80): 96 inches (2440 mm) with 1/2-inch (13-mm) rod.
    d. NPS 4 and NPS 6 (DN 100 and DN 150): 96 inches (2440 mm) with 5/8-inch (16-mm) rod.
21. Install supports for vertical glass piping every 96 inches (2440 mm).
22. Support piping and tubing not listed above according to MSS SP-69.

G. Neutralization Tank Installation
1. Install exterior collection **OR** neutralization, **as directed**, tanks, complete with appurtenances indicated.
    a. Set tops of tank covers flush with finished surface where covers occur in pavements. Set covers 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
    b. Include initial fill of limestone for neutralization tanks.
2. Install interior neutralization tanks on smooth and level concrete base **OR** floor surface, **as directed**. Include full initial charge of limestone.

H. Neutralization System Installation
1. Install neutralization systems on smooth and level concrete base **OR** floor surface, **as directed**. Include neutralizing solutions and full initial charge of limestone.

I. Manhole Installation
1. General: Install manholes, complete with appurtenances and accessories indicated. Comply with requirements in Division 02 Section "Sanitary Sewerage".
2. Set tops of manhole frames and covers flush with finished surface where manholes occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.

J. Leak-Detection System Installation
1. Single-Pipe, Chemical-Waste Sewerage Piping: Install leak-detection system below piping.
2. Double-Containment Piping: Install leak-detection system in piping annular space.
3. Manholes: Install leak-detection system around bottom of exterior.
4. Install panel in location indicated.

K. Concrete Placement
1. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for concrete supports.
2. Place cast-in-place concrete according to ACI 318/318R.

L. Connections
1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.
3. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch (150-mm) overlap, with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
4. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
5. Install piping adjacent to equipment to allow service and maintenance.

M. Labeling And Identification
1. Comply with requirements in Division 15 Section "Identification For Plumbing Piping And Equipment" for labeling of equipment and piping.
   a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
   b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

N. Field Quality Control
1. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place and again at completion of Project.
   a. Defects requiring correction include the following:
      1) Alignment: Less than full diameter of inside of pipe is visible between inspection points.
      2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      3) Crushed, broken, cracked, or otherwise damaged piping.
      4) Hydrostatic Tests for Drainage Piping:
         a) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile (4.6 L/mm of nominal pipe size per kilometer) of pipe, during 24-hour period.
         b) Close openings in system and fill with water.
         c) Purge air and refill with water.
         d) Disconnect water supply.
         e) Test and inspect joints for leaks.
      5) Air Tests for Drainage Piping: Comply with UNI-B-6.
   b. Leaks and loss in test pressure constitute defects that must be repaired.
   c. Submit separate reports for each test.
2. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.
3. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled neutralization systems and leak-detection systems and their installation, including piping and electrical connections, and to assist in testing.
   b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Chemical-waste piping will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

O. Startup Service
1. Perform startup service for neutralization systems and leak-detection systems.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Neutralization Systems:
      1) Verify that neutralization system is installed and connected according to the Contract Documents.
      2) Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 15.
      3) Install neutralizing solutions and limestone.
      4) Energize circuits.
      5) Start and run systems through complete sequence of operations.

6) Adjust operating controls.

c. Leak-Detection Systems:

1) Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 15.

2) Energize circuits.

3) Adjust operating controls.

P. Adjusting

1. Adjust neutralization-system set points.
2. Adjust leak-detection-system control and device settings.

Q. Cleaning

1. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

b. Clean piping by flushing with potable water.

R. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain neutralization systems and leak-detection systems.

S. Piping Schedule

1. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.
2. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:

a. NPS 2 to NPS 4 (DN 50 to DN 100): High-silicon-iron, hub-and-plain-end pipe and fittings and calked **OR** High-silicon-iron, mechanical-joint pipe and fittings and coupled, **as directed**, joints.

b. NPS 2 to NPS 4 (DN 50 to DN 100): Stainless-steel drainage pipe and fittings and gasketed joints.

c. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PE drainage pipe and fittings and heat-fusion joints.

d. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PP drainage pipe and fittings and electrofusion joints.

e. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PVC drainage pipe and fittings and solvent-cemented joints.

f. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): PVDF drainage pipe and fittings and electrofusion joints.

g. NPS 2 to NPS 4 (DN 50 to DN 100): Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.

h. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): Glass pipe and fittings and coupled joints.

i. NPS 6 (DN 150): High-silicon-iron, hub-and-plain-end pipe and fittings and calked **OR** High-silicon-iron, mechanical-joint pipe and fittings and coupled, **as directed**, joints.

j. NPS 6 (DN 150): Stainless-steel drainage pipe and fittings and gasketed joints.

k. NPS 6 (DN 150): PE drainage pipe and fittings and heat-fusion joints.

l. NPS 6 (DN 150): PP drainage pipe and fittings and electrofusion joints.

m. NPS 6 (DN 150): PVC drainage pipe and fittings and solvent-cemented joints.

n. NPS 6 (DN 150): PVDF drainage pipe and fittings and electrofusion joints.

o. NPS 6 (DN 150): Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.

p. NPS 6 (DN 150): Glass pipe and fittings and coupled joints.

q. NPS 8 to NPS 12 (DN 200 to DN 300): High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
r. NPS 8 to NPS 12 (DN 200 to DN 300): PP drainage pipe and fittings and electrofusion joints.
s. NPS 8 to NPS 12 (DN 200 to DN 300): PVC drainage pipe and fittings and solvent-cemented joints.
t. NPS 8 to NPS 12 (DN 200 to DN 300): PVDF drainage pipe and fittings and electrofusion joints.
u. NPS 8 to NPS 12 (DN 200 to DN 300): Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
v. NPS 15 (DN 375): High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
w. NPS 15 (DN 375): NPS 16 (DN 400) centrifugally cast **OR** NPS 14 (DN 350) filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.

3. Underground, Double-Containment, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
   a. NPS 2 to NPS 12 (DN 50 to DN 300): PE double-containment drainage pipe and fittings.
   b. NPS 2 to NPS 12 (DN 50 to DN 300): PP double-containment drainage pipe and fittings.
   c. NPS 2 to NPS 12 (DN 50 to DN 300): PP/PVC double-containment drainage pipe and fittings.
   d. NPS 2 to NPS 12 (DN 50 to DN 300): PVDF double-containment drainage pipe and fittings.
   e. NPS 2 to NPS 12 (DN 50 to DN 300): PVDF/PVC double-containment drainage pipe and fittings.
4. Aboveground Chemical-Waste Piping: Use any of the following piping materials for each size range:
   a. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and electrofusion **OR** mechanical, **as directed**, joints.
   b. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
   c. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVDF drainage piping and electrofusion **OR** mechanical, **as directed**, joints.
   d. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 6 (DN 50 to DN 150) high-silicon-iron piping with hub-and-plain ends and calked joints.
   e. NPS 1-1/2 to NPS 4 (DN 40 to DN 100): High-silicon-iron piping with mechanical-joint ends, mechanical couplings, and coupled joints.
   f. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) stainless-steel drainage piping with socket-and-spigot ends and gasketed joints.
   g. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Borosilicate glass pipe and fittings, couplings, and coupled joints.
   h. NPS 8 to NPS 12 (DN 200 to DN 300): PVC drainage pipe and fittings and solvent-cemented joints.
   i. NPS 8 to NPS 12 (DN 200 to DN 300): High-silicon-iron piping with hub-and-plain ends and calked joints.
5. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use any of the following piping materials for each size range:
   a. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PP drainage piping and electrofusion joints.
   b. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVC drainage piping and solvent-cemented joints.
   c. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PVDF drainage piping and electrofusion joints.
   d. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) high-silicon-iron piping with hub-and-plain ends and calked joints.
   e. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100) stainless-steel drainage piping with socket-and-spigot ends and gasketed joints.

f. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): Borosilicate glass piping with covering, couplings, and coupled joints.
g. NPS 1-1/2 to NPS 6 (DN 40 to DN 150): PE **OR** PP **OR** PP/PVC **OR** PVDF **OR** PVDF/PVC, **as directed**, double-containment drainage piping and manufacturer's standard joints.
h. NPS 8 (DN 200): PVC drainage piping and solvent-cemented joints.
i. NPS 8 (DN 200): High-silicon-iron piping with hub-and-plain ends and calked joints.
j. NPS 8 (DN 200): PE **OR** PP **OR** PP/PVC **OR** PVDF **OR** PVDF/PVC, **as directed**, double-containment drainage piping and manufacturer's standard joints.
k. NPS 10 and NPS 12 (DN 250 and DN 300): PVC drainage piping and solvent-cemented joints.
l. NPS 10 to NPS 15 (DN 250 to DN 375): High-silicon-iron piping with hub-and-plain ends and calked joints.

END OF SECTION 15341

Task	Specification	Specification Description
15421	02452	Storm Drainage
15422	02242	Piped Utilities Basic Materials And Methods
15423	02455b	Sanitary Sewerage
15423	15110	Storm Drainage Piping Specialties

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SECTION 15424 - ELECTRIC, DOMESTIC WATER HEATERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for electric, water heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following electric water heaters:
   a. Household, small-capacity electric water heaters.
   b. Household, storage electric water heaters.
   c. Household, collector-to-tank, solar-electric water heaters.
   d. Household, collector-to-tank, heat-exchanger-coil, solar-electric water heaters.
   e. Flow-control, instantaneous electric water heaters.
   f. Thermostat-control, instantaneous electric water heaters.
   g. Light-commercial electric water heaters.
   h. Commercial electric booster heaters.
   i. Commercial, storage electric water heaters.
   j. Compression tanks.
   k. Water heater accessories.

C. Submittals
1. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
   a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with ASHRAE/IESNA 90.1-2004, Section 7 - "Service Water Heating."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
3. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
4. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Structural failures including storage tank and supports.

2) Faulty operation of controls.
3) Deterioration of metals, metal finishes, and other materials beyond normal use.

b. Warranty Period(s): From date of Substantial Completion:
1) Household Electric Water Heaters:
a) Storage Tank: Five **OR** Six **OR** 10, **as directed**, years.
b) Controls and Other Components: Two **OR** Three, **as directed**, years.
2) Instantaneous Electric Water Heaters: One **OR** Two **OR** Five, **as directed**, year(s).
3) Light-Commercial Electric Water Heaters:
a) Storage Tank: Three **OR** Five, **as directed**, years.
b) Controls and Other Components: Two **OR** Three, **as directed**, years.
4) Commercial Electric Water Heaters:
a) Storage Tank: Three **OR** Five, **as directed**, years.
b) Controls and Other Components: Three **OR** Five, **as directed**, years.
5) Compression Tanks: One year.

1.2 PRODUCTS

A. Household Electric Water Heaters
1. Household, Small-Capacity Electric Water Heaters: Comply with UL 174.
a. Storage-Tank Construction: Corrosion-resistant metal or steel with corrosion-resistant coating, **as directed**.
1) Tappings: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
b. Factory-Installed Storage-Tank Appurtenances:
1) Drain Valve: ASSE 1005, if tank has drain outlet. Provide hose-end drain valve in piping for water heaters without drain outlet. Hose-end drain valves are specified in Division 15 Section "Domestic Water Piping Specialties".
2) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
3) Jacket: Steel with enameled finish.
4) Heating Element: Electric, screw-in immersion type.
5) Temperature Control: Adjustable thermostat.
6) Safety Control: High-temperature-limit cutoff device or system.
7) Power Supply Cord: 24 to 72 inches (610 to 1830 mm) with plug.
8) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
2. Household, Standard **OR** Tabletop, **as directed**, Storage Electric Water Heaters: Comply with UL 174.
a. Storage-Tank Construction: Steel.
1) Tappings: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
b. Factory-Installed Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.

5) Jacket: Steel with enameled finish.
   a) Standard: Cylindrical shape.
   b) Tabletop: Rectangular shape, with flat-top work surface and raised back.
6) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
7) Heating Elements: Two; electric, screw-in immersion type with 12 kW or less total, and wired for nonsimultaneous operation, unless otherwise indicated.
8) Temperature Control: Adjustable thermostat for each element.
9) Safety Control: High-temperature-limit cutoff device or system.
10) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

3. Household, Collector-to-Tank, Solar-Electric Water Heaters: Comply with UL 174 with piping and electrical connections for UL 1279 solar collector system.
   a. Storage-Tank Construction: Steel.
      1) Tappings: ASME B1.20.1 pipe thread.
      2) Pressure Rating: 150 psig (1035 kPa).
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
   b. Factory-Installed Storage-Tank Appurtenances:
      1) Sensor electrical connections and tank stud for sensor.
      2) Anode Rod: Replaceable magnesium.
      3) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      4) Drain Valve: ASSE 1005.
      5) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
      6) Jacket: Steel with enameled finish.
      7) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
      8) Heating Element: One; electric, screw-in immersion type with 6 kW or less.
      9) Temperature Control: Adjustable thermostat for each element.
      10) Safety Control: High-temperature-limit cutoff device or system.
      11) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
4. Household, Collector-to-Tank, Heat-Exchanger-Coil, Solar-Electric Water Heaters: Comply with UL 174 with integral coil-type heat exchanger.
   a. Storage-Tank Construction: Steel.
      1) Tappings: ASME B1.20.1 pipe thread.
      2) Pressure Rating: 150 psig (1035 kPa).
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
   b. Factory-Installed Storage-Tank Appurtenances:
      1) Anode Rod: Replaceable magnesium.
      2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      3) Drain Valve: ASSE 1005.
      4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
      5) Jacket: Steel with enameled finish.
      6) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
      7) Heat Exchanger: Corrosion-resistant-metal immersion coil.
      8) Heating Element: One; electric, screw-in immersion type with 6 kW or less.
      9) Temperature Control: Adjustable thermostat for each element.
      10) Safety Control: High-temperature-limit cutoff device or system.

11) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

B. Instantaneous Electric Water Heaters
1. Flow-Control, Instantaneous Electric Water Heaters: Comply with UL 499 for tankless electric (water heater) heating appliance.
a. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
1) Connections: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Heating Element: Resistance heating system.
4) Temperature Control: Flow-control fitting.
5) Safety Control: High-temperature-limit cutoff device or system.
6) Jacket: Aluminum or steel with enameled finish or plastic.
b. Support: Bracket for wall mounting.
2. Thermostat-Control, Instantaneous Electric Water Heaters: Comply with UL 499 for tankless electric (water heater) heating appliance.
a. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
1) Connections: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Heating Element: Resistance heating system.
4) Temperature Control: Thermostat.
5) Safety Control: High-temperature-limit cutoff device or system.
6) Jacket: Aluminum or steel with enameled finish or plastic.
b. Support: Bracket for wall mounting.

C. Light-Commercial Electric Water Heaters
1. Description: Comply with UL 174 for household, storage electric water heaters.
a. Storage-Tank Construction: Steel, vertical arrangement.
1) Tappings: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
b. Factory-Installed Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
5) Jacket: Steel with enameled finish.
6) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
7) Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation, unless otherwise indicated.
8) Temperature Control: Adjustable thermostat for each element.
9) Safety Control: High-temperature-limit cutoff device or system.
10) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
c. Special Requirements: NSF 5 construction with legs for off-floor installation.

D. Commercial Electric Water Heaters
1. Commercial Electric Booster Heaters: Comply with UL 1453 requirements for booster-type water heaters.
   a. Storage-Tank Construction: Corrosion-resistant metal **OR** Steel, **as directed**.
      1) Tappings: ASME B1.20.1 pipe thread.
      2) Pressure Rating: 150 psig (1035 kPa).
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
   b. Factory-Installed Storage-Tank Appurtenances:
      1) Anode Rod: Replaceable magnesium.
      2) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
      3) Insulation: Comply with ASHRAE/IESNA 90.1.
      4) Jacket: Rectangular shaped, with stainless-steel front panel, unless otherwise indicated.
      5) Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
         a) Option: Booster heaters with 9 kW or less total may have 2 or 3 elements.
         b) Staging: Input not exceeding 18 kW per step.
      6) Temperature Control: Adjustable thermostat, to setting of at least 180 deg F (82 deg C).
      7) Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
      8) Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3, combination temperature and pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
      9) Gages: Combination temperature and pressure type or separate thermometer and pressure gage.
   c. Special Requirements: NSF 5 construction with brackets for undercounter **OR** legs for floor, **as directed**, installation.
2. Commercial, Storage Electric Water Heaters: Comply with UL 1453 requirements for storage-tank-type water heaters.
   a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel horizontal **OR** vertical, **as directed**, arrangement.
      1) Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      2) Pressure Rating: 150 psig (1035 kPa).
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
   b. Factory-Installed Storage-Tank Appurtenances:
      1) Anode Rod: Replaceable magnesium.
      2) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
      3) Insulation: Comply with ASHRAE/IESNA 90.1.
      4) Jacket: Steel with enameled finish.
      5) Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
         a) Staging: Input not exceeding 18 kW per step.
      6) Temperature Control: Adjustable thermostat.
      7) Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
      8) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include

pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

c. Special Requirements: NSF 5 construction.

d. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

E. Compression Tanks

1. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

a. Construction:

1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.

2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

3) Air-Charging Valve: Factory installed.

F. Water Heater Accessories

1. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

2. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.

3. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 (DN 25) drain outlet with ASME B1.20.1 pipe thread.

4. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Include dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.

5. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

6. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).

7. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that are capable of isolating each water heater and of providing balanced flow through each water heater.

8. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.

9. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig- (172.5-kPa-) maximum outlet pressure, unless otherwise indicated.

10. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

G. Source Quality Control

1. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

2. Hydrostatically test commercial, **as directed**, water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

3. Prepare test reports.

1.3 EXECUTION

A. Water Heater Installation

1. Install commercial water heaters on concrete bases.

a. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
b. Concrete base construction requirements are specified in Division 15 Section "Common Work Results For Plumbing".

2. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
3. Install seismic restraints for light-commercial and commercial water heaters. Anchor to substrate.
4. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
5. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
6. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 15 Section "Domestic Water Piping Specialties" for hose-end drain valves.
7. Install thermometer on outlet piping of water heaters. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.
8. Install thermometers on inlet and outlet piping of household, collector-to-tank, solar-electric water heaters. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.
9. Install pressure gage(s) on inlet and outlet of commercial electric water- heater piping. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for pressure gages.
10. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 15 Section "General-duty Valves For Plumbing Piping" for general-duty valves and to Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.
11. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.
12. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
13. Fill water heaters with water.
14. Charge compression tanks with air.

B. Connections
1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
a. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
b. Operational Test: After electrical circuitry has been energized, confirm proper operation.
c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial and instantaneous electric water heaters.

END OF SECTION 15424

SECTION 15424a - FUEL-FIRED, DOMESTIC WATER HEATERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for fuel-fired water heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following fuel-fired water heaters:
   a. Household, atmospheric, storage, gas water heaters.
   b. Household, direct-vent, storage, gas water heaters.
   c. Household, power-vent, storage, gas water heaters.
   d. Instantaneous, tankless, gas water heaters.
   e. Commercial, atmospheric, storage, gas water heaters.
   f. Commercial, power-burner, storage, gas water heaters.
   g. Commercial, power-vent, storage, gas water heaters.
   h. Commercial, high-efficiency, gas water heaters.
   i. Commercial, coil-type, finned-tube, gas water heaters.
   j. Commercial, grid-type, finned-tube, gas water heaters.
   k. Household, oil-fired water heaters.
   l. Commercial, oil-fired water heaters.
   m. Large-capacity, oil-fired water heaters.
   n. Dual-fuel, gas and oil-fired water heaters.
   o. Compression tanks.
   p. Water heater accessories.

C. Definitions
1. LP Gas: Liquefied-petroleum fuel gas.

D. Submittals
1. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
   a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with ASHRAE/IESNA 90.1-2004, Section 7 - "Service Water Heating."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment". Include the following:
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE/IESNA 90.1-2004Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
3. ASME Compliance:

a. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
b. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

4. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Structural failures including storage tank and supports.
      2) Faulty operation of controls.
      3) Deterioration of metals, metal finishes, and other materials beyond normal use.
   b. Warranty Period(s): From date of Substantial Completion:
      1) Household, Gas Water Heaters:
         a) Storage Tank: Five **OR** Six **OR** 10, **as directed**, years.
         b) Controls and Other Components: Two **OR** Three, **as directed**, years.
      2) Instantaneous, Gas Water Heaters:
         a) Heat Exchanger: Five years.
         b) Controls and Other Components: Three years.
      3) Commercial, Gas Water Heaters:
         a) Storage Tank: Three **OR** Five, **as directed**, years.
         b) Controls and Other Components: Three **OR** Five, **as directed**, years.
      4) Oil-Fired Water Heaters:
         a) Storage Tank: Three **OR** Five, **as directed**, years.
         b) Burner and Controls: One **OR** Two **OR** Three, **as directed**, year(s).
         c) Other Components: Three **OR** Five, **as directed**, years.
      5) Dual-Fuel Water Heaters:
         a) Storage Tank: Three **OR** Five, **as directed**, years.
         b) Burner and Controls: One **OR** Two **OR** Three, **as directed**, year(s).
         c) Other Components: Three **OR** Five, **as directed**, years.
      6) Compression Tanks: One year.

1.2 PRODUCTS

A. Household, Gas Water Heaters

1. Household, Atmospheric, Storage, Gas Water Heaters: Comply with ANSI Z21.10.1/CSA 4.1.
   a. Storage-Tank Construction: Steel.
      1) Tappings: ASME B1.20.1 pipe thread.
      2) Pressure Rating: 150 psig (1035 kPa).
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
   b. Factory-Installed, Storage-Tank Appurtenances:
      1) Anode Rod: Replaceable magnesium.
      2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      3) Drain Valve: ASSE 1005.
      4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
      5) Jacket: Steel with enameled finish.
      6) Burner: For use with atmospheric water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.

7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
8) Temperature Control: Adjustable thermostat.
9) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
10) Combination Temperature and Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

c. Draft Hood: Low-profile-type, draft diverter; complying with ANSI Z21.12.

d. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.

2. Household, Direct-Vent, Storage, Gas Water Heaters: Comply with ANSI Z21.10.1/CSA 4.1.

a. Storage-Tank Construction: Steel.
1) Tappings: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

b. Factory-Installed, Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
5) Jacket: Steel with enameled finish.
6) Burner: For use with direct-vent water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
8) Temperature Control: Adjustable thermostat.
9) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
10) Combination Temperature and Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

c. Direct-Vent System: Through-wall **OR** Through-roof, **as directed**, coaxial- or double-channel, vent assembly with water heater manufacturers' outside intake/exhaust screen.

3. Household, Power-Vent, Storage, Gas Water Heaters: Comply with ANSI Z21.10.1/CSA 4.1.

a. Storage-Tank Construction: Steel.
1) Tappings: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

b. Factory-Installed, Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
5) Jacket: Steel with enameled finish.
6) Burner: For use with power-vent water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
8) Temperature Control: Adjustable thermostat.
9) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
10) Combination Temperature and Pressure Relief Valve: ANSI Z21.22/CSA 4.4. Include relieving capacity at least as great as heat input, and include pressure

setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

c. Power-Vent System: Exhaust fan, interlocked with burner.

B. Instantaneous, Gas Water Heaters

1. Description: Comply with ANSI Z21.10.3/CSA 4.3, except storage is not required.

a. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.

1) Tappings: ASME B1.20.1 pipe thread.

2) Pressure Rating: 150 psig (1035 kPa).

3) Heat Exchanger: Copper tubing.

4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.

5) Burner: For use with tankless water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.

6) Automatic Ignition: Manufacturer's proprietary system for automatic, gas ignition.

7) Temperature Control: Adjustable thermostat.

8) Jacket: Metal with enameled finish or plastic.

b. Support: Bracket for wall mounting.

C. Commercial, Gas Water Heaters

1. Commercial, Atmospheric, Storage, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) working-pressure rating.

1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.

b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

b. Factory-Installed, Storage-Tank Appurtenances:

1) Anode Rod: Replaceable magnesium.

2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.

3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.

4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.

5) Jacket: Steel with enameled finish.

6) Burner: For use with atmospheric water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.

7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.

8) Temperature Control: Adjustable thermostat.

9) Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

10) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

c. Special Requirements: NSF 5 construction.

d. Draft Hood: Draft diverter; complying with ANSI Z21.12.

e. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.

f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

2. Commercial, Power-Burner, Storage, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) working-pressure rating.

1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.

b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

b. Factory-Installed, Storage-Tank Appurtenances:

1) Anode Rod: Replaceable magnesium.

2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.

3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.

4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.

5) Jacket: Steel with enameled finish.

6) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

c. Burner: Comply with UL 795 for power-burner water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.

1) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.

d. Temperature Control: Adjustable thermostat.

e. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

f. Special Requirements: NSF 5 construction.

g. Draft Hood: Draft diverter; complying with ANSI Z21.12.

h. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

3. Commercial, Power-Vent, Storage, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) working-pressure rating.

1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.

b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

b. Factory-Installed, Storage-Tank Appurtenances:

1) Anode Rod: Replaceable magnesium.

2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
5) Jacket: Steel with enameled finish.
6) Burner: For use with power-vent water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
7) Automatic Ignition: ANSI Z21.20, electric, automatic, gas-ignition system.
8) Temperature Control: Adjustable thermostat.
9) Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
10) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valve with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

c. Special Requirements: NSF 5 construction.
d. Power-Vent System: Exhaust fan, interlocked with burner.
e. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

4. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.
a. Description: Manufacturer's proprietary design to provide at least 84 **OR** 85 **OR** 88 **OR** 95, **as directed**, percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
b. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.
1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
c. Factory-Installed, Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
5) Jacket: Steel with enameled finish.
6) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
d. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
e. Temperature Control: Adjustable thermostat.
f. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
g. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

h. Draft Hood: Draft diverter; complying with ANSI Z21.12.

5. Commercial, Coil-Type, Finned-Tube, Gas Water Heaters: Comply with ANSI Z21.13 for hot-water boilers.
   a. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.
   b. Boiler Construction: ASME code with 160-psig (1100-kPa) working-pressure rating for hot-water-boiler-type water heater.
      1) Heat Exchanger: Helix or spiral, finned-copper-tube coils with bronze headers.
      2) Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
   c. Boiler Appurtenances:
      1) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire boiler except connections and controls.
      2) Jacket: Steel with enameled finish.
      3) Burner: For use with coil-type, finned-tube water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
      4) Temperature Control: Adjustable, storage tank temperature-control fitting and flow switch, interlocked with circulator and burner.
      5) Safety Control: Automatic, high-temperature-limit cutoff device or system.
      6) Automatic Ignition: Intermittent electronic ignition complying with ANSI Z21.20.
   d. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
   e. Support: Steel base or skids.
   f. Draft Hood: Draft diverter; complying with ANSI Z21.12.
   g. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.
   h. Hot-Water Storage Tank: Connected with piping to circulating pump and water heater.
      1) Construction: According to ASME Boiler and Pressure Vessel Code: Section VIII, steel with 150-psig (1035-kPa) **OR** 125-psig (860-kPa), **as directed**, working-pressure rating.
      2) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
      5) Jacket: Steel with enameled finish.
      6) Anode Rods: Factory installed, magnesium.
      7) Drain Valve: Corrosion-resistant metal complying with ASSE 1005, factory installed.
      8) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
   i. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
   j. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.

k. Mounting: Water heater, tank, and accessories factory mounted on skids.

6. Commercial, Grid-Type, Finned-Tube, Gas Water Heaters: Comply with ANSI Z21.13 for hot-water boilers.
   a. Description: Packaged unit with boiler, storage tank, pump, piping, and controls.
   b. Boiler Construction: ASME code with 160-psig (1100-kPa) working-pressure rating for hot-water-boiler-type water heater.
      1) Heat Exchanger: Horizontal, straight, finned-copper tubes with bronze headers.
      2) Connections: Factory fabricated of materials compatible with boiler. Attach to boiler before testing.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
   c. Boiler Appurtenances:
      1) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire boiler except connections and controls.
      2) Jacket: Steel with enameled finish.
      3) Burner: For use with grid-type, finned-tube water heaters and for natural-gas **OR** LP-gas, **as directed**, fuel.
      4) Temperature Control: Adjustable, storage tank temperature-control fitting and flow switch, interlocked with circulator and burner.
      5) Safety Control: Automatic, high-temperature-limit cutoff device or system.
      6) Automatic Ignition: Intermittent electronic ignition complying with ANSI Z21.20.
   d. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.
   e. Support: Steel base or skids.
   f. Draft Hood: Draft diverter; complying with ANSI Z21.12.
   g. Automatic Damper: ANSI Z21.66, electrically operated **OR** mechanically activated **OR** thermally activated, **as directed**, automatic-vent-damper device with size matching draft hood.
   h. Hot-Water Storage Tank: Connected with piping to circulating pump and water heater.
      1) Construction: According to ASME Boiler and Pressure Vessel Code: Section VIII, steel with 150-psig (1035-kPa) **OR** 125-psig (860-kPa), **as directed**, working-pressure rating.
      2) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      4) Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
      5) Jacket: Steel with enameled finish.
      6) Anode Rods: Factory installed, magnesium.
      7) Drain Valve: Corrosion-resistant metal complying with ASSE 1005, factory installed.
      8) Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
   i. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.

j. Piping: Copper tubing; copper, solder-joint fittings; and brazed or flanged joints.
k. Mounting: Water heater, tank, and accessories factory mounted on skids.

D. Oil-Fired Water Heaters
1. Household, Oil-Fired Water Heaters: Comply with UL 732 for storage water heaters.
a. Storage-Tank Construction: Steel.
1) Tappings: ASME B1.20.1 pipe thread.
2) Pressure Rating: 150 psig (1035 kPa).
3) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
b. Factory-Installed, Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
5) Jacket: Steel with enameled finish.
6) Temperature Control: Adjustable thermostat.
7) Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
8) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
c. Oil Burner: Comply with UL 296 for use with No. 2 fuel oil.
d. Draft Regulator: Barometric type or adjustable-damper device.
2. Commercial, Oil-Fired Water Heaters: Comply with UL 732 for storage water heaters.
a. Storage-Tank Construction: ASME-code **OR** Non-ASME-code, **as directed**, steel with 150-psig (1035-kPa) minimum working-pressure rating.
1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
b. Factory-Installed, Storage-Tank Appurtenances:
1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
5) Jacket: Steel with enameled finish.
6) Temperature Control: Adjustable thermostat.
7) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
c. Oil Burners: Comply with UL 296 for use with No. 2 fuel oil.
d. Safety Control: Automatic, high-temperature-limit cutoff device or system.
e. Draft Regulator: Barometric type or adjustable-damper device.

f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

3. Large-Capacity, Oil-Fired Water Heaters: Comply with UL 732 for storage water heaters except when capacity is greater than 120 gal. (454 L).
   a. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.
      1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
   b. Factory-Installed, Storage-Tank Appurtenances:
      1) Anode Rod: Replaceable magnesium.
      2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
      3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
      4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
      5) Jacket: Steel with enameled finish.
      6) Temperature Control: Adjustable thermostat.
      7) Safety Control: Automatic, high-temperature-limit cutoff device or system.
      8) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
   c. Oil Burner: Comply with UL 296 for use with No. 2 fuel oil.
   d. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
   e. Draft Regulator: Barometric type or adjustable-damper device.
   f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

E. Dual-Fuel Water Heaters
   1. Description: Comply with ANSI Z21.10.3/CSA 4.3 or UL 732 requirements appropriate for dual-fuel, gas and oil-fired water heaters.
      a. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.
         1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
            a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
            b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
         2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
         3) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
      b. Factory-Installed, Storage-Tank Appurtenances:

1) Anode Rod: Replaceable magnesium.
2) Dip Tube: Provide unless cold-water inlet is near bottom of tank.
3) Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
4) Insulation: Comply with ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.
5) Jacket: Steel with enameled finish.
6) Temperature Control: Adjustable thermostat.
7) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

c. Dual-Fuel Burners: Combination gas-oil burner assembly, complying with appropriate requirements of UL 795; or comply with UL 296 for oil burners for No. 2 fuel oil and UL 795 for natural-gas **OR** LP-gas, **as directed**, fuel.

d. Safety Control: Automatic, high-temperature-limit cutoff device or system.

e. Vent Connection: According to standards of authorities having jurisdiction for dual-fuel water heaters.

f. Building Automation System Interface: Normally closed dry contacts for enabling and disabling water heater.

F. Compression Tanks

1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

a. Construction:

1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
3) Air-Charging Valve: Factory installed.

G. Water Heater Accessories

1. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.
2. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.
3. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.
4. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
   a. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
   b. Oil-Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.
5. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.
   a. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
   b. Oil-Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.
6. Water Heater Stand and Drain Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 (DN 25) drain outlet with ASME B1.20.1 pipe thread.
7. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Provide dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.
8. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.
9. Drain Pans: Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).

10. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.
11. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004 or ASHRAE 90.2-2004, **as directed**.

H. Source Quality Control
1. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
2. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
3. Prepare test reports.

1.3 EXECUTION

A. Water Heater Installation
1. Install commercial water heaters on concrete bases.
   a. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
   b. Concrete base construction requirements are specified in Division 15 Section "Common Work Results For Plumbing".
2. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
3. Install seismic restraints for commercial water heaters. Anchor to substrate.
4. Install gas water heaters according to NFPA 54.
5. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.
6. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
7. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.
8. Install oil-fired water heaters according to NFPA 31.
9. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
10. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
11. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 15 Section "Domestic Water Piping Specialties" for hose-end drain valves.
12. Install thermometer on outlet piping of water heaters. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.
13. Install pressure gage(s) on inlet and outlet piping of commercial, fuel-fired water heater piping. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for pressure gages.
14. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 15 Section "General-duty Valves For Plumbing Piping" for general-duty valves and to Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.

15. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
16. Fill water heaters with water.
17. Charge compression tanks with air.

B. Connections
1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
   a. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   b. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instantaneous and commercial water heaters.

END OF SECTION 15424a

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SECTION 15425 - DOMESTIC WATER HEAT EXCHANGERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for heat exchangers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following heat exchangers:
a. Heating-fluid-in-coil, instantaneous heat exchangers.
b. Domestic-water-in-coil, instantaneous heat exchangers.
c. Heating-fluid-in-U-tube-coil, instantaneous heat exchangers.
d. Circulating, compact heat exchangers.
e. Circulating, storage heat exchangers.
f. Noncirculating, compact heat exchangers.
g. Noncirculating, storage heat exchangers.
h. Brazed-plate heat exchangers.
i. Frame-and-plate heat exchangers.
j. Heat reclaimers.
k. Compression tanks.
l. Heat-exchanger accessories.

C. Submittals
1. Product Data: For each type and size of heat exchanger indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.
7. Warranty: Special warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Where ASME-code construction is indicated, fabricate and label heat-exchanger storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with water.

E. Warranty
1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of heat exchangers that fail in materials or workmanship within specified warranty period.
a. Failures include, but are not limited to, the following:
1) Structural failures including heat exchanger, storage tank, and supports.
2) Faulty operation of controls.
3) Deterioration of metals, metal finishes, and other materials beyond normal use.
b. Warranty Period(s): From date of Substantial Completion:

1) Instantaneous Heat Exchangers:
   a) Tube Coil and Shell: One year.
   b) Controls and Other Components: One year.
2) Circulating, Storage Heat Exchangers:
   a) Storage Tank: Five years.
   b) Tube Coil: Five years.
   c) Controls and Other Components: Three years.
3) Noncirculating, Storage Heat Exchangers:
   a) Storage Tank: Five years.
   b) Tube Coil: Five years.
   c) Controls and Other Components: Three years.
4) Plate Heat Exchangers:
   a) Brazed-Plate Type: One year.
   b) Plate-and-Frame Type: One year.
5) Heat Reclaimers: One year.
6) Compression Tanks: One year.

1.2 PRODUCTS

A. Instantaneous Heat Exchangers
   1. Heating-Fluid-in-Coil, Instantaneous Heat Exchangers:
      a. Description: Packaged assembly of tank, heat-exchanger coils, controls, and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in heat-exchanger coils.
      b. Construction: ASME-code, negligible-capacity, copper-lined, carbon-steel shell with 150-psig (1035-kPa) minimum working-pressure rating.
         1) Tappings: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.
            a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
            b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
         2) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
         3) Heat-Exchanger Coils: Copper **OR** Copper nickel **OR** Stainless-steel, **as directed**, helix-wound coils for heating fluid with pressure rating equal to or greater than heating-fluid supply pressure.
         4) Temperature Control: Adjustable thermostat that operates control valve and that is capable of maintaining outlet-water temperature within 4 deg F (2 deg C) of setting.
         5) Safety Control: Automatic, high-temperature-limit cutoff device or system.
         6) Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
      c. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, and piping. Include components fitted for pneumatic control.
      d. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping. Include components fitted for pneumatic control.
         1) Exception: Steam trap is not required if manufacturer's written instructions direct that it not be used.
      e. Stand: Factory fabricated for floor mounting.

2. Domestic-Water-in-Coil, Instantaneous Heat Exchangers:
   a. Description: Tankless, packaged assembly of heat-exchanger coils, controls, and specialties for heating domestic water in coils with steam in shell.
   b. Construction: ASME code, with cast-iron or steel shell for steam.
      1) Cast-Iron Shell Pressure Rating: 75 psig (517 kPa).
      2) Steel Shell Pressure Rating: 150 psig (1035 kPa).
      3) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
   c. Heat-Exchanger Coils: Spiral-wound, copper or copper-alloy **OR** stainless-steel, **as directed**, coils for domestic water.
   d. Temperature Control: Adjustable thermostat that operates steam-control valve and that is capable of maintaining outlet-water temperature within 3 deg F (2 deg C) of setting.
   e. Safety Control: Automatic, high-temperature-limit cutoff device or system.
   f. Miscellaneous Components: Strainers, steam-control valve, steam trap, valves, and piping.
   g. Stand: Factory fabricated for floor mounting.
3. Heating-Fluid-in-U-Tube-Coil, Instantaneous Heat Exchangers:
   a. Description: Tankless, packaged assembly of heat-exchanger coil, controls, and specialties for heating domestic water in shell with heating hot water **OR** steam, **as directed**, in coil.
   b. Construction: ASME-code, negligible-capacity, copper-lined, carbon-steel or copper-alloy shell with 150-psig (1035-kPa) minimum working-pressure rating.
      1) Configuration: Horizontal **OR** Vertical, **as directed**.
      2) Shell Tappings: Factory fabricated of materials compatible with water heater shell. Attach tappings to shell before testing and labeling.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      3) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire shell and nozzle except connections and controls.
      4) Heat-Exchanger Coil: Copper, double-wall **OR** single-wall, **as directed**, U tubes for heating fluid.
         a) Tube Pressure Rating: Equal to or greater than heating-fluid supply pressure.
   c. Temperature Control: Adjustable thermostat that operates steam-control valve and that is capable of maintaining outlet-water temperature within 5 deg F (3 deg C) of setting.
   d. Safety Control: Automatic, high-temperature-limit cutoff device or system.
   e. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into shell.
   f. Miscellaneous Components for Heating Hot-Water Unit: Control valve, valves, and piping. Include components fitted for pneumatic control.
   g. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping. Include components fitted for pneumatic control.
   h. Stand: Factory fabricated for floor mounting.

B. Circulating, Storage Heat Exchangers
   1. Circulating, Compact Heat Exchangers:
      a. Description: Packaged, small-capacity, hot-water storage tank with heat-exchanger coil; circulator; controls; and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.

b. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.

c. Storage Tank Construction: ASME-code, vertical; copper-silicon or corrosion-resistant metal with 150-psig (1035-kPa) working-pressure rating. Include nozzle and head for heat-exchanger tube coil.

1) Configuration: Vertical.

2) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.

a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.

b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

3) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.

d. Heat-Exchanger Coil: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32), **as directed**, diameter, vented, double-wall, copper or copper-alloy, U tubes with tube sheet and supporting baffles.

1) Heat-Exchanger Pressure Rating: Equal to or greater than heating-fluid supply pressure.

e. Temperature Control: Adjustable thermostat.

f. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.

g. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.

h. Gages: Factory-mounted thermometer and pressure gage.

i. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.

1) Pump Control: Sensor for operating pump and control valve.

j. Miscellaneous Components for Heating Hot-Water Units: Control valve, valves, and piping.

k. Miscellaneous Components for Steam Units: Strainers, steam-control valve, steam trap, valves, and piping.

l. Support: Factory mounted on skids.

m. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.

2. Circulating, Storage Heat Exchangers:

a. Description: Packaged, large-capacity, hot-water storage tank with heat-exchanger coil, circulator, controls, and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.

b. Flow Pattern: Standard-flow arrangement, with water from bottom of storage tank circulated across heat-exchanger coil and returned to tank. Include hot-water outlet located at top of tank and temperature sensor in tank.

c. Flow Pattern: Reverse-flow arrangement, with water from storage tank drawn across heat-exchanger coil and returned to bottom of tank. Include hot-water outlet and temperature sensor located in or at coil shell.

d. Storage Tank Construction: ASME-code steel with 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working-pressure rating. Include nozzle and head for heat-exchanger tube coil.

1) Configuration: Horizontal **OR** Vertical, **as directed**.
2) Manhole: 11 by 15 inches (280 by 380 mm) in end head of horizontal **OR** sidewall of vertical, **as directed**, storage tank shell.
3) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
   a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
   b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
4) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
5) Anode Rods: Factory installed, magnesium.
6) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.

e. Heat-Exchanger Coil: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32), **as directed**, diameter, vented, double-wall, copper or copper-alloy, U tubes with tube sheet and supporting baffles.
   1) Heat-Exchanger Pressure Rating: Equal to or greater than heating-fluid supply pressure.

f. Temperature Control: Adjustable temperature aquastat, mounted in storage tank shell head, unless otherwise indicated.

g. Safety Control: Automatic, high-temperature-limit cutoff device or system. Include automatic low-water cutoff device or system.

h. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.

i. Gages: Factory-mounted thermometer and pressure gage.

j. Circulating Pump: UL 778, all-bronze, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3. Include mechanical seals, 125-psig (860-kPa) minimum working-pressure rating, and 225 deg F (107 deg C) continuous-water-temperature rating.
   1) Pump Control: Sensor for operating pump and control valve.

k. Support: Factory mounted on skids.

l. Energy Management System Interface: Normally closed dry contacts for enabling and disabling heat exchanger.

C. Noncirculating, Storage Heat Exchangers

1. Compact Heat Exchangers:

a. Description: Hot-water storage tank with integral heat-exchanger coil, controls, and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.

b. Storage Tank Shell Construction: Steel or stainless steel with 150-psig (1035-kPa) working-pressure rating.
   1) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   3) Insulation: Complying with ASHRAE/IESNA 90.1 or ASHRAE 90.2, and suitable for operating temperature. Surround entire tank except connections and controls.
   4) Jacket: Steel with enameled finish, unless otherwise indicated.
   5) Anode Rods for Steel Tanks: Factory installed, magnesium.

c. Heat-Exchanger Coil: Copper or stainless-steel coil assembly, permanently installed inside storage tank, for heating fluid. Include working-pressure rating equal to or greater than heating-fluid supply pressure.
d. Temperature Control: Adjustable thermostat.
e. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include relief valve with relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select relief valve with sensing element that extends into storage tank.

2. Storage Heat Exchangers:
   a. Description: Assembly of hot-water storage tank with separate heat-exchanger coil; controls; and specialties for heating domestic water with heating hot water **OR** steam, **as directed**, in coil.
   b. Storage Tank Construction: ASME-code steel with 125-psig (860-kPa) **OR** 150-psig (1035-kPa), **as directed**, working-pressure rating. Include nozzle and head for heat-exchanger tube coil.
      1) Configuration: Horizontal **OR** Vertical, **as directed**.
      2) Manhole: 11 by 15 inches (280 by 380 mm) in end head of horizontal **OR** sidewall of vertical, **as directed**, storage tank shell.
      3) Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing and labeling.
         a) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
         b) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
      4) Lining: Cement **OR** Glass **OR** Nickel plate **OR** Phenolic coating **OR** Sheet copper, **as directed**, complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
      5) Anode Rods: Factory installed, magnesium.
      6) Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire storage tank and nozzle except connections and controls.
   c. Heat-Exchanger Coil: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32), **as directed**, diameter, vented, double-wall, copper or copper-alloy, U tubes with tube sheet and supporting baffles.
      1) Heat-Exchanger Pressure Rating: Equal to or greater than heating-fluid supply pressure.
   d. Temperature Control: Adjustable temperature aquastat, mounted in storage tank shell head, unless otherwise indicated.
   e. Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3, for combination temperature and pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select one relief valve with sensing element that extends into storage tank.
   f. Support: Factory mounted on skids.

D. Plate Heat Exchangers
   1. Brazed-Plate Heat Exchangers:
      a. Description: Assembly of heat-exchanger plates, permanently brazed together, for using heating hot water **OR** steam, **as directed**, to heat domestic water.
      b. Working-Pressure Rating: 150 psig (1035 kPa) **OR** 200 psig (1380 kPa) **OR** 250 psig (1725 kPa) **OR** 400 psig (2760 kPa), **as directed**, minimum.
      c. Plate Construction: Single **OR** Vented, double, **as directed**, wall.
      d. Plate Material: ASTM A 666, Type 316 stainless steel.
      e. Connections: Stainless steel; threaded.

2. Frame-and-Plate Heat Exchangers:
   a. Description: Assembly of nonfixed-position, heat-exchanger plates, with frame, for using heating hot water **OR** steam, **as directed**, to heat domestic water.
   b. Working-Pressure Rating: 150 psig (1035 kPa) **OR** 200 psig (1380 kPa) **OR** 250 psig (1725 kPa) **OR** 400 psig (2760 kPa), **as directed**, minimum.
   c. Frame:
      1) Carrying and Guide Bars: Carbon steel **OR** Stainless steel, **as directed**.
      2) Fixed, Frame Plate; Pressure Plate; Support Column; and Nuts and Bolts: Carbon steel.
   d. Channel Plates:
      1) Type: Single **OR** Vented, double, **as directed**, wall.
      2) Material: ASTM A 666, Type 304 or 316 stainless steel.
      3) Gasket Material: Butyl or acrylonitrile-butadiene rubber, suitable for potable water.
   e. Connections: Stainless steel suitable for potable water.
      1) NPS 2 (DN 50) and Smaller: Threaded.
      2) NPS 2-1/2 (DN 65) and Larger: Flanged.
   f. Protective Shroud: Steel, covering channel plates.
   g. Insulation: Complying with ASHRAE/IESNA 90.1, unless otherwise indicated, and suitable for operating temperature. Surround entire heat exchanger except connections.

E. Heat Reclaimers
1. Description: Waste-heat recovery device complying with and listed according to UL 207 for heat reclaimers. Device includes vertical drainage tube with helical, domestic water preheat coil around drainage tube.
   a. Drainage Tube: ASTM B 306, Type DWV, center, copper drainage tube of size indicated.
   b. Water Preheat Coil: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube, of size indicated attached to drainage tube.
      1) Working-Pressure Rating: 150 psig (1035 kPa) on potable-water supply tubing.
   c. Capacity and Characteristics:
      1) NPS 2 (DN 50) Drainage Tube:
         a) Domestic Water Preheat Coil: NPS 3/8 (DN 10).
         b) Unit Height: 20 inches (508 mm) **OR** 24 inches (610 mm) **OR** 30 inches (762 mm), **as directed**.
      2) NPS 3 (DN 80) Drainage Tube:
         a) Domestic Water Preheat Coil: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**.
         b) Unit Height: 30 inches (762 mm) **OR** 40 inches (1016 mm) **OR** 60 inches (1524 mm), **as directed**.
      3) NPS 4 (DN 100) Drainage Tube:
         a) Domestic-Water Preheat Coil: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**.
         b) Unit Height: 30 inches (762 mm) **OR** 40 inches (1016 mm) **OR** 60 inches (1524 mm), **as directed**.

F. Compression Tanks
1. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
   a. Construction:
      1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
      2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
      3) Air-Charging Valve: Factory installed.
   b. Capacity and Characteristics:
      1) Working-Pressure Rating: 100 psig (690 kPa) **OR** 150 psig (1035 kPa), **as directed**.

2) Capacity Acceptable: 2 gal. (7.6 L) **OR** 4 gal. (15.1 L) **OR** 7 gal. (26.5 L) **OR** 10 gal. (37.9 L), **as directed**, minimum.

G. Heat-Exchanger Accessories
1. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than working-pressure rating of heat exchanger. Select relief valves with sensing element that extends into heat-exchanger storage tank.
2. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than working-pressure rating of heat exchanger.
3. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.
4. Source Quality Control
5. Test and inspect heat-exchanger storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
6. Hydrostatically test commercial heat-exchanger storage tanks before shipment to minimum of one and one-half times pressure rating.
7. Prepare test reports.

1.3 EXECUTION

A. Heat-Exchanger Installation
1. Install heat exchangers on concrete bases.
   a. Concrete base construction requirements are specified in Division 15 Section "Common Work Results For Plumbing".
2. Install heat exchangers level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
3. Anchor heat exchangers to substrate.
4. Install seismic restraints for heat exchangers. Anchor to substrate.
5. Install temperature and pressure relief valves in top portion of storage tank shells of heat exchangers with domestic water storage. Use relief valves with sensing elements that extend into shells. Extend relief-valve outlet, with drain piping same as water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
6. Install combination temperature and pressure relief valves in water piping for heat exchangers without storage. Extend relief-valve outlet, with drain piping same as water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
7. Install heat-exchanger drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for heat exchangers that do not have tank drains. Refer to Division 15 Section "Domestic Water Piping Specialties" for hose-end drain valves.
8. Install thermometer on each heat-exchanger domestic-water inlet and outlet piping, and install thermometer on each heat-exchanger heating-fluid inlet and outlet piping. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for thermometers.
9. Install pressure gages on heat-exchanger heating-fluid piping. Refer to Division 15 Section "Meters And Gages For Plumbing Piping" for pressure gages.
10. Fill heat exchangers with water.
11. Charge compression tanks with air.

B. Connections
1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to heat exchangers to allow service and maintenance. Arrange piping for easy removal of heat exchangers.

3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
   a. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
   b. Operational Test: After electrical circuitry has been energized, confirm proper operation.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace heat exchangers that do not pass tests and inspections and retest as specified above.

D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION 15425

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Task	Specification	Specification Description
15425	15424	Electric, Domestic Water Heaters
15425	15424a	Fuel-Fired, Domestic Water Heaters

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SECTION 15451 - PLUMBING FIXTURES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following conventional plumbing fixtures and related components:
   a. Faucets for lavatories, bathtubs, bathtub/showers, showers, and sinks.
   b. Laminar-flow faucet-spout outlets.
   c. Flushometers.
   d. Toilet seats.
   e. Protective shielding guards.
   f. Fixture supports.
   g. Interceptors.
   h. Shower receptors.
   i. Dishwasher air-gap fittings.
   j. Disposers.
   k. Hot-water dispensers.
   l. Water closets.
   m. Urinals.
   n. Bidets.
   o. Lavatories.
   p. Commercial sinks.
   q. Shampoo bowls.
   r. Wash fountains.
   s. Bathtubs.
   t. Individual showers.
   u. Group showers.
   v. Whirlpool bathtubs.
   w. Kitchen sinks.
   x. Service sinks.
   y. Service basins.
   z. Laundry trays.
   aa. Sacristy sinks.

C. Definitions

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
3. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.
4. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.
5. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
6. FRP: Fiberglass-reinforced plastic.
7. PMMA: Polymethyl methacrylate (acrylic) plastic.
8. PVC: Polyvinyl chloride plastic.

9. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

D. Submittals
1. Product Data: For each type of plumbing fixture indicated.
2. LEED Submittal:
   a. Product Data for Credit WE 2, 3.1, and 3.2: Documentation indicating flow and water consumption requirements.
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Operation and maintenance data
5. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" **OR** Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act", **as directed**; for plumbing fixtures for people with disabilities.
3. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
4. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
5. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
6. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
   a. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
   b. Plastic Bathtubs: ANSI Z124.1.
   c. Plastic Lavatories: ANSI Z124.3.
   d. Plastic Laundry Trays: ANSI Z124.6.
   e. Plastic Mop-Service Basins: ANSI Z124.6.
   f. Plastic Shower Enclosures: ANSI Z124.2.
   g. Plastic Sinks: ANSI Z124.6.
   h. Plastic Urinal Fixtures: ANSI Z124.9.
   i. Plastic Whirlpool Bathtubs: ANSI Z124.1 and ASME A112.19.7M.
   j. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
   k. Slip-Resistant Bathing Surfaces: ASTM F 462.
   l. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
   m. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
   n. Stainless-Steel Residential Sinks: ASME A112.19.3.
   o. Vitreous-China Fixtures: ASME A112.19.2M.
   p. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
   q. Water-Closet, Flushometer Tank Trim: ASSE 1037.
   r. Whirlpool Bathtub Fittings: ASME A112.19.8M.
7. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   a. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
   b. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   c. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   d. Faucets: ASME A112.18.1.
   e. Hose-Connection Vacuum Breakers: ASSE 1011.
   f. Hose-Coupling Threads: ASME B1.20.7.
   g. Integral, Atmospheric Vacuum Breakers: ASSE 1001.

h. NSF Potable-Water Materials: NSF 61.
i. Pipe Threads: ASME B1.20.1.
j. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
k. Supply Fittings: ASME A112.18.1.
l. Brass Waste Fittings: ASME A112.18.2.

8. Comply with the following applicable standards and other requirements specified for bathtub, bathtub/shower, and shower faucets:
   a. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
   b. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
   c. Deck-Mounted Bath/Shower Transfer Valves: ASME 18.7.
   d. Faucets: ASME A112.18.1.
   e. Hand-Held Showers: ASSE 1014.
   f. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
   g. Hose-Coupling Threads: ASME B1.20.7.
   h. Manual-Control Antiscald Faucets: ASTM F 444.
   i. Pipe Threads: ASME B1.20.1.
   j. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
   k. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   l. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
9. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   a. Atmospheric Vacuum Breakers: ASSE 1001.
   b. Brass and Copper Supplies: ASME A112.18.1.
   c. Dishwasher Air-Gap Fittings: ASSE 1021.
   d. Manual-Operation Flushometers: ASSE 1037.
   e. Plastic Tubular Fittings: ASTM F 409.
   f. Brass Waste Fittings: ASME A112.18.2.
   g. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
10. Comply with the following applicable standards and other requirements specified for miscellaneous components:
   a. Disposers: ASSE 1008 and UL 430.
   b. Dishwasher Air-Gap Fittings: ASSE 1021.
   c. Flexible Water Connectors: ASME A112.18.6.
   d. Floor Drains: ASME A112.6.3.
   e. Grab Bars: ASTM F 446.
   f. Hose-Coupling Threads: ASME B1.20.7.
   g. Hot-Water Dispensers: ASSE 1023 and UL 499.
   h. Off-Floor Fixture Supports: ASME A112.6.1M.
   i. Pipe Threads: ASME B1.20.1.
   j. Plastic Shower Receptors: ANSI Z124.2.
   k. Plastic Toilet Seats: ANSI Z124.5.
   l. Supply and Drain Protective Shielding Guards: ICC A117.1.
   m. Whirlpool Bathtub Equipment: UL 1795.

F. Warranty
1. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Commercial Applications: One **OR** Three, **as directed**, year(s) from date of Substantial Completion.
   b. Warranty Period for Residential Applications of Shells: Five **OR** 20 **OR** 30, **as directed**, years from date of Substantial Completion.
   c. Warranty Period for Residential Applications of Pumps and Blowers: Five **OR** 20, **as directed**, years from date of Substantial Completion.

d. Warranty Period for Residential Applications of Electronic Controls: Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Lavatory Faucets

1. Description: Single-control mixing **OR** Single-control nonmixing **OR** Two-handle mixing, **as directed**, valve. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   a. Body Material: Commercial, solid brass **OR** General-duty, solid brass **OR** General-duty, solid brass or copper or brass underbody with brass cover plate **OR** General-duty, copper or brass underbody with brass cover plate **OR** Residential, nonmetallic underbody with brass cover plate **OR** Residential, nonmetallic underbody with nonmetallic cover plate, **as directed**.
   b. Finish: Polished chrome plate **OR** Polished brass **OR** Nonmetallic, **as directed**.
   c. Maximum Flow Rate: 0.5 gpm (1.5 L/min.) **OR** 2.2 gpm (8.3 L/min.) **OR** 2.5 gpm (9.5 L/min.), **as directed**.
      OR
      Maximum Flow: 0.25 gal. (0.95 L).
   d. Centers: 3-3/8 inches (86 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** Single hole **OR** Adjustable, **as directed**.
   e. Mounting: Deck, exposed **OR** Deck, concealed **OR** Back/wall, exposed **OR** Back/wall, concealed, **as directed**.
   f. Valve Handle(s): Lever **OR** Knob **OR** Knob, nonmetallic **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Push button **OR** Not applicable, **as directed**.
   g. Inlet(s): NPS 3/8 (DN 10) tubing, plain end **OR** NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
   h. Spout: Rigid **OR** Swing **OR** Rigid, gooseneck **OR** Swivel, gooseneck, **as directed**, type.
   i. Spout Outlet: Aerator **OR** Spray **OR** Laminar flow **OR** Plain end **OR** Spray, 0.5 gpm (1.5 L/min.), **as directed**.
   j. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor **OR** Self-closing, metering, **as directed**.
   k. Drain: Not required **OR** Pop up **OR** Stopper with chain **OR** Grid **OR** Lift and turn, **as directed**.
   l. Tempering Device: Mechanical **OR** Thermostatic **OR** Pressure balance **OR** Not required, **as directed**.

B. Bathtub Faucets

1. Description: Single-control mixing **OR** Two-handle mixing **OR** Three-handle mixing **OR** Push-button, metering, nonmixing, **as directed**, valve. Include hot- and cold-water indicators and tub spout. Coordinate faucet inlets with supplies.
   a. Body Material: Solid brass.
   b. Finish: Polished chrome plate **OR** Polished brass, **as directed**.
   c. Mounting: Deck **OR** Exposed, over rim **OR** Wall, **as directed**.
   d. Valve Handle(s): Lever **OR** Knob **OR** Knob, nonmetallic **OR** Cross, four arm **OR** Not applicable, **as directed**.
   e. Bathtub Spout: Chrome-plated brass with diverter, **as directed**.
   f. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
   g. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.

C. Bathtub/Shower Faucets

1. Description: Single-handle pressure-balance **OR** thermostatic **OR** thermostatic/pressure-balance, **as directed**, valve for bathtub and for shower. Include hot- and cold-water indicators; check stops; tub spout; and shower head, arm, and flange. Coordinate faucet inlets with supplies; coordinate outlet with diverter valve.
   a. Body Material: Solid brass with nonmetallic trim, **as directed**.
   b. Finish: Polished chrome plate **OR** Polished brass, **as directed**.
   c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
   d. Diverter Valve: Integral **OR** Not integral, **as directed**, with mixing valve.
   e. Mounting: Wall.
   f. Bathtub Spout: Chrome-plated brass with diverter, **as directed**.
   g. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
   h. Antiscald Device: Integral with mixing valve **OR** Separate unit, **as directed**.
   i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
   j. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.
   k. Backflow Protection Device for Hand-Held Shower: Required **OR** Not required, **as directed**.
   l. Shower Head Type: Ball joint **OR** Without ball joint **OR** Ball joint and head integral with mounting flange **OR** Integral with mounting flange **OR** Hand held, slide-bar mounted **OR** Hand held, hook mounted, **as directed**.
   m. Shower Head Material: Metallic **OR** Nonmetallic **OR** Combined, metallic and nonmetallic, **as directed**, with chrome-plated finish.
   n. Spray Pattern: Fixed **OR** Adjustable, **as directed**.
   o. Integral Volume Control: Required **OR** Not required, **as directed**.
   p. Shower-Arm Flow-Control Fitting: Not required **OR** 1.5 gpm (5.7 L/min.) **OR** 2.0 gpm (7.6 L/min.), **as directed**.

D. Shower Faucets
1. Description: Single-handle pressure-balance **OR** thermostatic **OR** thermostatic and pressure-balance, **as directed**, valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and outlet with diverter valve.
   a. Body Material: Solid brass with nonmetallic trim, **as directed**.
   b. Finish: Polished chrome plate **OR** Polished brass, **as directed**.
   c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
   d. Diverter Valve: Not required **OR** Integral with mixing valve **OR** Not integral with mixing valve, **as directed**.
   e. Mounting: Exposed **OR** Concealed, **as directed**.
   f. Backflow Protection Device for Hand-Held Shower: Required **OR** Not required, **as directed**.
   g. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
   h. Antiscald Device: Integral with mixing valve **OR** Separate unit **OR** Not required, **as directed**.
   i. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
   j. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.
   k. Shower Head Type: Ball joint **OR** Without ball joint **OR** Ball joint and head integral with mounting flange **OR** Integral with mounting flange **OR** Hand held, slide-bar mounted **OR** Hand held, hook mounted, **as directed**.
   l. Shower Head Material: Metallic **OR** Nonmetallic **OR** Combined, metallic and nonmetallic, **as directed**, with chrome-plated finish.
   m. Spray Pattern: Fixed **OR** Adjustable, **as directed**.
   n. Integral Volume Control: Required **OR** Not required, **as directed**.
   o. Shower-Arm Flow-Control Fitting: Not required **OR** 1.5 gpm (5.7 L/min.) **OR** 2.0 gpm (7.6 L/min.), **as directed**.

p. Temperature Indicator: Not required **OR** Integral with faucet, **as directed**.

E. Sink Faucets

1. Description: Kitchen faucet with spray, three-hole fixture **OR** Kitchen faucet with spray, four-hole fixture **OR** Kitchen faucet without spray **OR** Laundry tray faucet **OR** Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook **OR** Bar sink faucet, **as directed**. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
   a. Body Material: Commercial, solid brass **OR** General-duty, solid brass **OR** General-duty, solid brass or copper or brass underbody with brass cover plate **OR** General-duty, copper or brass underbody with brass cover plate **OR** Residential, nonmetallic underbody with brass cover plate **OR** Residential, nonmetallic underbody with nonmetallic cover plate, **as directed**.
   b. Finish: Polished chrome plate **OR** Polished brass **OR** Nonmetallic **OR** Polished or rough brass **OR** Rough brass, **as directed**.
   c. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
   d. Mixing Valve: Single control **OR** Two-lever handle, **as directed**.
   e. Backflow Protection Device for Hose Outlet: Required **OR** Not required, **as directed**.
   f. Backflow Protection Device for Side Spray: Required **OR** Not required, **as directed**.
   g. Centers: 3-3/8 inches (86 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** Single hole **OR** Adjustable, **as directed**.
   h. Mounting: Deck **OR** Back/wall, **as directed**, exposed **OR** concealed, **as directed**.
   i. Handle(s): Lever **OR** Knob **OR** Knob, nonmetallic **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Not applicable, **as directed**.
   j. Inlet(s): NPS 3/8 (DN 10) plain-end tubing **OR** NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
   k. Spout Type: Rigid, solid brass **OR** Rigid, solid brass with wall brace **OR** Swing, round tubular **OR** Swing, shaped tube **OR** Swing, solid brass **OR** Rigid gooseneck **OR** Swivel gooseneck, **as directed**.
   l. Spout Outlet: Aerator **OR** Swivel aerator/spray **OR** Spray **OR** Laminar flow **OR** Hose thread **OR** Plain end, **as directed**.
   m. Vacuum Breaker: Required **OR** Not required, **as directed**.
   n. Operation: Compression, manual **OR** Noncompression, manual **OR** Sensor, **as directed**.
   o. Drain: Not required **OR** Pop up **OR** Stopper with chain **OR** Grid **OR** Lift and turn, **as directed**.

F. Laminar-Flow Faucet-Spout Outlets

1. Description: Chrome-plated-brass faucet-spout outlet that produces non-aerating, laminar stream. Include male or female thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

G. Flushometers

1. Description: Flushometer for urinal-type **OR** water-closet-type, **as directed**, fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, **as directed**, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.
   a. Internal Design: Diaphragm **OR** Piston, **as directed**, operation.
   b. Style: Exposed **OR** Concealed, **as directed**.
   c. Inlet Size: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**.
   d. Trip Mechanism: Oscillating, lever-handle actuator **OR** Mechanical, push-button actuator with stainless-steel access plate **OR** Hydraulic, push-button actuator **OR** Foot-pedal actuator **OR** Hard-wired, electric-sensor actuator **OR** Battery-operated sensor actuator, **as directed**.

e. Consumption: 0.5 gal./flush (1.9 L/flush) **OR** 1.0 gal./flush (3.8 L/flush) **OR** 1.5 gal./flush (5.7 L/flush) **OR** 1.6 gal./flush (6.0 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
f. Tailpiece Size: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, and standard, **as directed**, length to top of bowl.

H. Toilet Seats
1. Description: Toilet seat for water-closet-type fixture.
a. Material: Molded, solid plastic with antimicrobial agent, **as directed**.
b. Configuration: Closed **OR** Open, **as directed**, front with **OR** without, **as directed**, cover.
c. Size: Elongated **OR** Regular, **as directed**.
d. Hinge Type: CK, check **OR** SS, self-sustaining **OR** SC, self-sustaining, check **OR** SR, self-raising, **as directed**.
e. Class: Residential **OR** Standard commercial **OR** Heavy-duty commercial, **as directed**.
f. Color: White **OR** Black, **as directed**.

I. Protective Shielding Guards
1. Protective Shielding Pipe Covers:
a. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply **OR** hot- and cold-water supplies, **as directed**, and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
2. Protective Shielding Piping Enclosures:
a. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

J. Fixture Supports
1. Water-Closet Supports:
a. Description: Combination carrier designed for accessible **OR** standard, **as directed**, mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
2. Urinal Supports:
a. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture **OR** Type II, urinal carrier with hanger and bearing plates, **as directed**, for wall-mounting, urinal-type fixture. Include steel uprights with feet.
b. Accessible-Fixture Support: Include rectangular steel uprights.
3. Lavatory Supports:
a. Description: Type I, lavatory carrier with exposed arms and tie rods **OR** Type II, lavatory carrier with concealed arms and tie rod **OR** Type III, lavatory carrier with hanger plate and tie rod, **as directed**, for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
b. Accessible-Fixture Support: Include rectangular steel uprights.
4. Sink Supports:
a. Description: Type I, sink carrier with exposed arms and tie rods **OR** Type II, sink carrier with hanger plate, bearing studs, and tie rod **OR** Type III, sink carrier with hanger plate and exposed arms, **as directed**, for sink-type fixture. Include steel uprights with feet.

K. Interceptors
1. Hair Interceptors:
a. Description: Manufactured unit with removable screen or strainer and removable cover; designed to trap and retain hair.
1) Material: Brass **OR** Stainless-steel, **as directed**, body.
2) Pipe Connections: NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**.
2. Sediment Interceptors:

a. Description: Manufactured unit with removable screens or strainer and removable cover; designed to trap and retain waste material.
   1) Material: Cast-iron or steel body with acid-resistant lining and coating **OR** Carbon-steel body with acid-resistant lining and coating **OR** Stainless-steel, **as directed**.
   2) Pipe Connections: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**.

L. Shower Receptors
1. Description: Cast-polymer **OR** FRP **OR** PMMA **OR** Precast-terrazzo **OR** Solid-surface, **as directed**, base for built-up-type shower fixture.
   1) Type: Standard, residential **OR** Handicapped/wheelchair, **as directed**.
   2) Size: 32 by 32 inches (813 by 813 mm) **OR** 36 by 36 inches (914 by 914 mm) **OR** 32 by 42 inches (813 by 1067 mm) **OR** 48 by 60 inches (1219 by 1524 mm), **as directed**.
   3) Color: White.
   4) Outlet: Cast-in-floor drain **OR** Drain, **as directed**, with NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.

M. Dishwasher Air-Gap Fittings
1. Description: Fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body, chrome-plated brass cover, **as directed**; and capacity of at least 5 gpm (0.32 L/s); and inlet pressure of at least 5 psig (35 kPa) at a temperature of at least 140 deg F (60 deg C). Include 5/8-inch- (16-mm-) ID inlet and 7/8-inch- (22-mm-) ID outlet hose connections.
2. Hoses: Rubber and suitable for temperature of at least 140 deg F (60 deg C).
   a. Inlet Hose: 5/8-inch (16-mm) ID and 48 inches (1219 mm) long.
   b. Outlet Hose: 7/8-inch (22-mm) ID and 48 inches (1219 mm) long.

N. Disposers
1. Description: Batch-feed **OR** Continuous-feed, **as directed**, household, food-waste disposer. Include reset button; wall switch; corrosion-resistant chamber with jam-resistant, cutlery- or stainless-steel grinder or shredder; NPS 1-1/2 (DN 40) outlet; quick-mounting, stainless-steel sink flange; antisplash guard; and combination cover/stopper.
   a. Type: Batch-feed **OR** Continuous-feed, **as directed**, household.
   b. Model: Not applicable **OR** Sound-insulated chamber **OR** Sound-insulated chamber and stainless-steel outer shell, **as directed**.
   c. Motor: 115-V ac, 1725 rpm, 1/3 **OR** 1/2 **OR** 3/4 **OR** 1, **as directed**, hp with overload protection.

O. Hot-Water Dispensers
1. Description: Gooseneck spout with lever-handle **OR** Spout with twist-knob or push-button, **as directed**, flow control, household-type dispenser with instant on-off control; insulated, corrosion-resistant-metal storage tank that is open to atmosphere; electric heating element; chrome-plated faucet or spout; removable strainer; thermostat control for water temperature up to 190 deg F (88 deg C); and thermal-overload protection.
   a. Storage Tank Capacity: 0.5 gal. (1.5 L).
   b. Heating Element: 750 W minimum, 115-V ac.

P. Water Closets
1. Water Closets, Wall-Mounting, Back-Outlet Type:
   a. Description Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet, vitreous-china fixture designed for flushometer-tank **OR** gravity-type tank **OR** flushometer valve, **as directed**, operation.
      1) Style: Close coupled **OR** One piece, **as directed**.
         a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet design.
         b) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.

c) Tank: Gravity type with trim **OR** Flushometer-tank type with trim and pressurized tank, **as directed**. Include cover.
d) Trip Mechanism: Lever-handle **OR** Push-button, **as directed**, actuator.
e) Color: White.

2) Supply: NPS 1/2 (DN 15) chrome-plated brass or copper with wheel-handle **OR** screwdriver **OR** loose-key, **as directed**, stop.

3) Style: Flushometer valve.

a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet **OR** blowout, **as directed**, design.
b) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
c) Color: White.

4) Fixture Support: Water-closet support <Insert designation> combination carrier.

2. Water Closets, Floor-Mounting, Floor-Outlet Type:

a. Description: Accessible, floor-mounting **OR** Floor-mounting, **as directed**, floor-outlet, vitreous-china fixture designed for gravity-type tank **OR** flushometer tank **OR** flushometer valve, **as directed**, operation.

1) Style: Close coupled **OR** One piece, **as directed**.

a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet design. Include bolt caps matching fixture.
b) Height: Standard **OR** Accessible **OR** Juvenile **OR** Child, **as directed**.
c) Design Consumption: 1 gal./flush (3.8 L/flush) **OR** 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
d) Tank: Gravity type with trim **OR** Flushometer-tank type with trim and pressurized tank, **as directed**. Include cover.
e) Trip Mechanism: Lever-handle **OR** Push-button, **as directed**, actuator.
f) Color: White.

2) Supply: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated brass or copper with wheel-handle **OR** screwdriver **OR** loose-key, **as directed**, stop.

3) Style: Flushometer valve.

a) Bowl Type: Elongated **OR** Round front, **as directed**, with siphon-jet **OR** reverse-trap **OR** blowout **OR** siphon-vortex **OR** siphon-wash **OR** washdown, **as directed**, design. Include bolt caps matching fixture.
b) Height: Standard **OR** Accessible **OR** Juvenile **OR** Child, **as directed**.
c) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
d) Color: White.

3. Water Closets, Floor-Mounting, Back-Outlet Type:

a. Description Accessible, floor-mounting **OR** Floor-mounting, **as directed**, back-outlet, vitreous-china fixture designed for gravity-tank **OR** flushometer-tank **OR** flushometer-valve, **as directed**, operation.

1) Style: Close coupled.

a) Bowl Type: Elongated with siphon-jet design. Include bolt caps matching fixture.
b) Height: Standard **OR** Accessible, **as directed**.
c) Design Consumption: 1.6 gal./flush (6 L/flush).
d) Tank: Gravity type with trim. Include cover.
e) Trip Mechanism: Lever-handle actuator.
f) Color: White.

2) Supply: NPS 1/2 (DN 15) chrome-plated brass or copper with wheel-handle **OR** screwdriver **OR** loose-key, **as directed**, stop.

3) Style: Flushometer valve.

a) Bowl Type: Elongated with siphon-jet design. Include bolt caps matching fixture.
b) Height: Standard **OR** Accessible, **as directed**.

c) Design Consumption: 1.6 gal./flush (6 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.
d) Color: White.
4) Wall Support: Manufactured waste fitting with seal and fixture bolts.

Q. Urinals
1. Urinals, Wall-Mounting, Back-Outlet Type:
a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet, vitreous-china fixture designed for flushometer valve operation.
1) Type: Blowout **OR** Siphon jet **OR** Blowout with extended shields **OR** Siphon jet with extended shields **OR** Washout with extended shields, **as directed**.
2) Strainer or Trapway: Integral cast strainer **OR** Separate removable strainer **OR** Open trapway, **as directed**, with integral trap.
3) Design Consumption: 0.5 gal./flush (1.9 L/flush) **OR** 1 gal./flush (3.8 L/flush) **OR** 1.5 gal./flush (5.7 L/flush), **as directed**.
4) Color: White.
5) Supply Spud Size: NPS 3/4 (DN 20) **OR** NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**.
6) Outlet Size: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**.
7) Fixture Support: Urinal chair carrier.
2. Urinals, Wall-Mounting, Bottom-Outlet Type:
a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, bottom-outlet, vitreous-china fixture designed for flushometer valve operation.
1) Type: Washout **OR** Washdown, **as directed**.
2) Strainer or Trapway: Integral cast strainer **OR** Separate removable strainer **OR** Open trapway, **as directed**.
3) Design Consumption: 0.5 gal./flush (1.9 L/flush) **OR** 1 gal./flush (3.8 L/flush), **as directed**.
4) Color: White.
5) Supply Spud Size: NPS 3/4 (DN 20).
6) Outlet Size: NPS 1-1/2 (DN 40).
7) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
8) Flushing Device: Fixture manufacturer's standard matching fixture.
9) Flushometer: **As directed.**
10) Fixture Support: Urinal chair carrier.
3. Urinals, Stall-Type, Bottom-Outlet:
a. Description Stall-type, bottom-outlet, vitreous-china fixture designed for flushometer valve operation.
4. Urinals, Wall-Mounting, Bottom-Outlet, Trough-Type:
a. Description: Wall-mounting, bottom-outlet, trough-type, enameled, cast-iron fixture modified for flushometer valve operation.
1) Style: Similar to wash sink with back and without pedestal.
2) Size: 36 inches (915 mm) **OR** 48 inches (1219 mm) **OR** 60 inches (1525 mm) **OR** 72 inches (1830 mm), **as directed**.
3) Color: White.
4) Drain: Separate removable dome strainer.
5) Design Consumption: Not applicable.
6) Supply: NPS 1/2 (DN 15).
7) Outlet Size: NPS 1-1/2 (DN 40).
8) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
9) Flushing Device: Fixture manufacturer's standard, with washdown pipe, matching fixture.

10) Fixture Support: Sink chair carrier.

5. Urinals, Wall-Mounting, Back-Outlet Dry Type:
   a. Description Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet dry, plastic **OR** vitreous-china, **as directed**, fixture designed for liquid-trap-seal operation.
      1) Type: Without water supply.
      2) Trap-Seal Method: Proprietary cartridge or trap system.
      3) Color: White.
      4) Outlet Size: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**. Include transition coupling, if required.
      5) Trap-Sealing Liquid: Proprietary.
      6) Fixture Support: Urinal chair carrier.

R. Bidets
1. Description: Floor-mounting, vitreous-china fixture with fittings.
   a. Type: With spray **OR** flushing rim **OR** spray and flushing rim, **as directed**, and overflow. Include bolt caps matching fixture.
   b. Faucet Hole Punching: One **OR** Two **OR** Three **OR** Four **OR** No, **as directed**, hole(s).
   c. Color: White.
   d. Faucet: Fixture manufacturer's standard, or two-valve supply, provided by fixture supplier, with vacuum breaker, diverter, submerged spray, **OR** over-rim filling, **as directed**, pop-up waste, and chrome-plated finish.
   e. Supplies: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.
   f. Drain Piping: NPS 1-1/4 (DN 32) chrome-plated, cast-brass P-trap; 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.

S. Lavatories
1. Lavatories, Wall-Mounting Type:
   a. Description: Accessible, wall-mounting **OR** Wall-mounting **OR** Wall-and-pedestal-mounting, **as directed**, enameled, cast-iron **OR** vitreous-china, **as directed**, fixture.
      1) Type: With back **OR** Ledge back **OR** Shelf back **OR** Slab **OR** Pedestal, **as directed**.
      2) Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**, rectangular.
      3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
      4) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
      5) Pedestal: Not required **OR** Required, **as directed**.
      6) Color: White.
      7) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
      8) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
      9) Drain: See faucet **OR** Grid **OR** Grid with offset waste, **as directed**.
         a) Location: Not applicable **OR** Near back of bowl, **as directed**.
      10) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
         OR
         Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.
         a) Exception: Omit P-trap if hair interceptor is required.
      11) Hair Interceptor: Not required.
      12) Protective Shielding Guard(s): **As directed**.

13) Fixture Support: Lavatory.

2. Lavatories, Counter-Mounting Type:
   a. Description: Accessible **OR** Counter-mounting **OR** Undercounter-mounting, **as directed**, enameled, cast-iron **OR** FRP **OR** PMMA **OR** porcelain-enameled, formed-steel **OR** solid-surface **OR** stainless-steel **OR** vitreous-china, **as directed** fixture.
      1) Type: Flat rim with ledge **OR** Self-rimming, **as directed**.
      2) Rectangular Lavatory Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**.
      3) Oval Lavatory Size: 19 by 16 inches (483 by 406 mm) **OR** 20 by 17 inches (508 by 432 mm), **as directed**.
      4) Round Lavatory Size: 18 inches (457 mm) **OR** 19 inches (483 mm), **as directed**, in diameter.
      5) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
      6) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
      7) Color: White.
      8) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
      9) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
      10) Drain: See faucet **OR** Grid **OR** Grid with offset waste, **as directed**.
         a) Location: Not applicable **OR** Near back of bowl, **as directed**.
      11) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
         OR
         Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.
         a) Exception: Omit P-trap if hair interceptor is required.
      12) Hair Interceptor: Not required.
      13) Protective Shielding Guard(s): **As directed**.
3. Lavatories, Countertop With Integral Bowl Type:
   a. Description: Countertop **OR** Accessible countertop, **as directed**, with integral bowl fixtures for mounting on base unit.
      1) Backsplash: Integral with countertop **OR** Separate, same material as countertop **OR** Not required, **as directed**.
      2) Overall Rectangular Top Size: 25 by 17 inches (635 by 432 mm) **OR** 31 by 19 inches (787 by 483 mm) **OR** 49 by 22 inches (1245 by 559 mm) **OR** 73 by 22 inches (1854 by 559 mm), **as directed**, with 1 **OR** 2 **OR** 3 **OR** 4, **as directed**, bowl(s).
         a) Bowl Size: Oval 19 by 16 inches (483 by 406 mm) **OR** 20 by 17 inches (508 by 432 mm), **as directed**.
      3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
      4) Faucet Hole Location: Countertop.
      5) Color: White.
      6) Faucet(s): Lavatory with pop-up waste **OR** with separate drain, **as directed**, for each bowl.
      7) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.
      8) Drain(s): See faucets **OR** Grid **OR** Grid with offset waste, **as directed**.
         a) Location: Not applicable **OR** Near back of bowl, **as directed**.
      9) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.

OR

Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.

10) Hair Interceptor(s): **As directed** for bowls as indicated.

11) Protective Shielding Guard(s): **As directed** for bowls as indicated.

4. Lavatories, For Wheelchair-Bound Persons:

a. Description: Accessible, wall-mounting, vitreous-china fixture designed for people in wheelchairs.

1) Type: Ledge back **OR** Shelf back **OR** Slab, **as directed**.

2) Size: 20 by 26 inches (508 by 660 mm) minimum; rectangular.

3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers **OR** Three holes, 8-inch (203-mm) centers **OR** Three holes, 12-inch (305-mm) centers, **as directed**.

4) Color: White.

5) Faucet: Lavatory for separate drain.

6) Supplies: NPS 3/8 (DN 10) chrome-plated copper with stops.

7) Drain: Grid **OR** Grid with offset waste, **as directed**.

8) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.

OR

Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, tubular waste to wall; and wall escutcheon.

9) Fixture Support: Lavatory.

T. Commercial Sinks

1. Commercial Sinks, Counter-Mounting Type:

a. Description: One-compartment **OR** Two-compartment **OR** Three-compartment, **as directed**, counter-mounting, stainless-steel commercial sink with backsplash.

1) Metal Thickness: 0.050 inch (1.3 mm).

2) Compartment (for single-compartment sink):

a) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.

i. Location: Centered in compartment **OR** Near back of compartment **OR** Near left side of compartment **OR** Near right side of compartment, **as directed**.

3) Each Compartment (for multiple-compartment sink):

a) Drains: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed.**

i. Location: Centered in compartment **OR** Near back of compartment, **as directed**.

4) Faucet(s): Sink.

a) Number Required: One **OR** Two, **as directed**.

b) Mounting: Deck.

5) Supplies: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**, chrome-plated copper with stops or shutoff valves.

6) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass **OR** copper pipe, **as directed**, waste to wall; continuous waste, **as directed**; and wall escutcheon(s).

2. Commercial Sinks, Freestanding Type:

a. Description: One-compartment **OR** Two-compartment **OR** Three-compartment, **as directed**, freestanding, stainless-steel commercial sink with backsplash.
   1) Metal Thickness: 0.050 inch (1.3 mm) **OR** 0.063 inch (1.6 mm), **as directed**.
   2) Compartment (for single-compartment sink):
      a) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.
         i. Location: Centered in compartment **OR** Near back of compartment **OR** Near left side of compartment **OR** Near right side of compartment, **as directed**.
   3) Each Compartment (for multiple-compartment sink):
      a) Drains: Grid with NPS 1-1/2 (DN 40) tailpiece and twist drain **OR** Grid with NPS 2 (DN 50) tailpiece and twist drain **OR** NPS 1-1/2 (DN 40) tailpiece with stopper **OR** NPS 1-1/2 (DN 40) tailpiece with pop-up waste, **as directed**.
         i. Location: Centered in compartment **OR** Near back of compartment, **as directed**.
   4) Drainboard(s): Not required **OR** Both **OR** Left **OR** Right, **as directed**, side(s).
      a) Dimensions Each: Not applicable.
   5) Supports: Adjustable-length, steel legs.
   6) Faucet(s): Sink.
      a) Number Required: One **OR** Two, **as directed**.
      b) Mounting: In backsplash.
   7) Supplies: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**, chrome-plated copper with stops or shutoff valves.
   8) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass **OR** copper pipe, **as directed**, waste to wall; continuous waste, **as directed**; and wall escutcheon(s).

3. Commercial Sinks, Handwash Type:
   a. Description: Wall-mounting, stainless-steel, commercial, handwash-sink fixture.
      1) Type: Basin with radius corners, back for faucet, and support brackets.
      2) Size; Approximately 17 by 16 by 5 inches (432 by 406 by 127 mm).
      3) Faucet: Back-mounting, chrome-plated, solid-brass, gooseneck type with individual valves.
      4) Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
      5) Drain: Grid.
      6) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
      7) Fixture Support: Sink for wall-mounting installation.

U. Shampoo Bowls
   1. Description: Enameled, cast-iron **OR** PMMA, **as directed**, fixture shaped for head rest. Include vacuum breaker, faucet, hose and spray, drain, and mounting brackets.
      a. Color: White.
      b. Supplies: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.
      c. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.
         OR
         Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; and wall escutcheon.
      d. Hair Interceptor: **As directed**
      e. Fixture Support for Counter Mounting: Brackets or forms.
         OR
         Fixture Support for Wall Mounting: Sink.

V. Wash Fountains

1. Wash Fountains, Freestanding Type:
   a. Description: Accessible, Circular, freestanding-design, wash-up fixture.
      1) Arrangement: Wash-up stations facing central spray head.
      2) Receptor Material: Precast terrazzo **OR** Stainless steel **OR** Solid surface, **as directed**, on base.
      3) Receptor Color or Finish: Not applicable.
      4) Size: 36- to 39-inch (914- to 990-mm) **OR** 54-inch (1370-mm), **as directed**, diameter.
      5) Number of Stations: Two **OR** Three **OR** Four **OR** Five **OR** Six **OR** Eight, **as directed**.
      6) Control: Collective **OR** Individual, **as directed**, push-button **OR** foot-pedal **OR** sensor, **as directed**, actuation with thermostatic valve and check stops or field-installed check valves.
      7) Liquid Soap Dispensers: Manual **OR** Sensor, **as directed**, for each station.
      8) Mounting: Floor.
      9) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves from bottom **OR** top, **as directed**.
      10) Shroud: Not required **OR** Stainless steel of size to cover supplies and vent piping, **as directed**.
      11) Drain: Grid with NPS 2 (DN 50) tailpiece.
      12) Trap Fitting: Not required **OR** NPS 2 (DN 50) trap with waste and vent connections, **as directed**.
      13) Drain Piping: NPS 1-1/2 (DN 40), **OR** NPS 2 (DN 50), **as directed**, waste to floor.
      14) Vent Piping: Not required **OR** NPS 1-1/2 (DN 40) to ceiling, **as directed**.
2. Wash Fountains, Semicircular Or Corner Type:
   a. Description: Accessible, Semicircular **OR** Corner, **as directed**, design, wash-up fixture.
      1) Arrangement: Wash-up stations facing central spray head.
      2) Receptor Material: Precast terrazzo **OR** Stainless steel **OR** Solid surface, **as directed**, on base.
      3) Receptor Color or Finish: Not applicable.
      4) Size: 36- to 39-inch (914- to 990-mm) **OR** 54-inch (1370-mm), **as directed**, diameter.
      5) Number of Stations: Two **OR** Three **OR** Four, **as directed**.
      6) Control: Collective **OR** Individual, **as directed**, push-button **OR** foot-pedal **OR** sensor, **as directed**, actuation with thermostatic valve and check stops or field-installed check valves.
      7) Liquid Soap Dispensers: Manual **OR** Sensor, **as directed**, for each station.
      8) Mounting: Floor and flush-to-wall with wall bracket.
      9) Supplies: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20), **as directed**, copper tubing with ball, gate, or globe valves.
      10) Drain: Grid with NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, tailpiece.
      11) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, P-trap, waste to wall, and wall flange.
3. Wash Fountains, Wall-Mounting Type:
   a. Description: Accessible, **as directed**, Flush-to-wall, **as directed**, linear design, wash-up fixture.
      1) Arrangement: Wash-up stations facing spray heads.
      2) Receptor Material: Precast terrazzo **OR** Stainless steel **OR** Solid surface, **as directed**, on base.
      3) Receptor Color or Finish: Not applicable.
      4) Number of Stations: One **OR** Two **OR** Three **OR** Four, **as directed**.
      5) Control: Collective **OR** Individual, **as directed**, push-button **OR** sensor, **as directed**, actuation with thermostatic valve and check stops or field-installed check valves.
      6) Liquid Soap Dispensers: Manual **OR** Sensor, **as directed**, for each station.

7) Mounting: Floor mounting with bracket for attaching to wall.
8) Faucet(s): Push-button **OR** Sensor-actuated, **as directed**, mixing valve with check stops.
9) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
10) Drain: Grid with NPS 1-1/2 (DN 40) tailpiece.
11) Drain Piping: NPS 1-1/2 (DN 40) P-trap, waste to wall, and wall flange.

W. Bathtubs
1. Description: Enameled, cast-iron **OR** FRP **OR** PMMA **OR** Porcelain-enameled, formed-steel, **as directed**, fixture.
a. Bathing Surface: Slip resistant.
b. Size: 48 by 30 inches (1220 by 765 mm) **OR** 60 by 30 inches (1525 by 765 mm) **OR** 66 by 30 inches (1680 by 765 mm), **as directed**, with front apron **OR** drop-in type, **as directed**.
c. Color: White.
d. Drain Location: Left **OR** Right, **as directed**, end.
e. Accessibility Options: Include grab bar and bench.
f. Faucet: Bathtub **OR** Bathtub/shower, **as directed**.
g. Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
h. Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
i. Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and waste.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap and waste.

X. Individual Showers
1. Individual Showers, Enclosure Type:
a. Description: Accessible, **as directed**, FRP **OR** PMMA, **as directed**, shower enclosure with slip-resistant bathing surface and shower rod with curtain.
1) Size: 36 by 34 inches (915 by 865 mm) **OR** 42 by 36 inches (1065 by 915 mm) **OR** 43 by 39 inches (1090 by 990 mm) **OR** 48 by 34 inches (1220 by 865 mm) **OR** 52 by 36 inches (1320 by 915 mm) **OR** 60 by 36 inches (1525 by 915 mm) **OR** 72 by 36 inches (1830 by 915 mm), **as directed**.
2) Surround: One piece or sealed, multiple piece, **as directed**.
OR
Surround: One piece.
3) Color: White.
4) Drain Location: Left side **OR** Center **OR** Right side, **as directed**.
5) Accessibility Options: Include grab bar and bench.
6) Faucet: Shower.
7) Drain: Grid, NPS 2 (DN 50).
2. Individual Showers, Built-Up Type:
a. Description: Components for built-up shower.
1) Receptor: Not required.
3. Individual Showers, Cabinet Type:
a. Description: Factory-fabricated, accessible, **as directed**, cabinet type with faucet and receptor.
1) Size: 30 by 30 inches (760 by 760 mm) **OR** 32 by 32 inches (815 by 815 mm) **OR** 36 by 36 inches (915 by 915 mm) **OR** 36 by 39 inches (915 by 990 mm) **OR** 45 by 39 inches (1145 by 990 mm), **as directed**.
2) Material: Steel **OR** Composite **OR** Plastic, **as directed**, front **OR** corner **OR** front and rear, **as directed**, access.
3) Color: Not applicable.
4) Accessibility Options: Grab bar and bench.
5) Faucet: Shower.

6) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves, **as directed**.
7) Drain: Grid, NPS 2 (DN 50).

Y. Group Showers
1. Group Showers, Column Type:
a. Description: Stainless-steel column fixture with two **OR** three **OR** four **OR** five **OR** six, **as directed**, individual showers.
1) Height to Shower Heads: 66 inches (1675 mm) **OR** 72 inches (1830 mm), **as directed**.
2) Control: Thermostatic **OR** Pressure-balance, **as directed**, valve with individual hot- and cold-water mixing valve operation.
OR
Control: Thermostatic valve with individual tempered-water supply and push-button **OR** sensor, **as directed**, operation.
3) Flow Control: 2 gpm (7.6 L/min.) **OR** 2.5 gpm (9.5 L/min.), **as directed**, for each shower head.
4) Liquid Soap Dispenser: For each shower.
5) Mounting: Floor flange.
6) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves from bottom **OR** top, **as directed**.
7) Shroud: Not required **OR** Stainless steel of size to cover supplies and vent piping, **as directed**.
8) Drain Fitting: NPS 3 (DN 80) **OR** NPS 4 (DN 100), **as directed**, outlet with NPS 2 (DN 50) vent, integral with base of column.
9) Vent Piping: Not required **OR** NPS 2 (DN 50) to ceiling, **as directed**.
2. Group Showers, Wall-Mounting Type:
a. Description: Wall-mounting fixture with stainless-steel surface enclosure with two **OR** three, **as directed**, individual showers.
1) Control: Thermostatic **OR** Pressure-balance, **as directed**, valve with individual hot- and cold-water mixing valve operation.
OR
Control: Thermostatic valve with individual tempered-water supply and push-button **OR** sensor, **as directed**, operation.
2) Flow Control: 2 gpm (7.6 L/min.) **OR** 2.5 gpm (9.5 L/min.), **as directed**, for each shower head.
3) Liquid Soap Dispenser: For each shower.
4) Mounting: Wall bracket.
5) Supplies: NPS 3/4 (DN 20) copper tubing with ball, gate, or globe valves.
3. Group Showers, Freestanding, Plastic Type:
a. Description: Freestanding, plastic group-shower fixture.
1) Number of Shower Stations: One **OR** Two **OR** Three **OR** Four, **as directed**, with individual self-closing control valve(s).
2) Number of Foot Wash Stations: One **OR** Two, **as directed**, with individual self-closing control valve(s).
3) Hose Bibb: Not **OR** One, **as directed**, required.
4) Control-Valve Mounting Height: 50 inches (1270 mm) **OR** 48 inches (1219 mm), **as directed**.
5) Material: Cast-filled-polymer plastic.
6) Color: Gray.
7) Internal Piping: Factory installed.
8) Mounting: Base flange with bolt holes.
4. Group Showers, Freestanding, Steel Type:
a. Description: Freestanding, steel group-shower fixture.
1) Number of Shower Stations: One **OR** Two, **as directed**, with individual self-closing control valve(s).

2) Number of Foot Wash Stations: One **OR** Two, **as directed**, with individual self-closing control valve(s).
3) Material: Painted steel pipe.
4) Color: Blue.
5) Internal Piping: Factory installed.
6) Mounting: Base flange with bolt holes.

Z. Whirlpool Bathtubs

1. Whirlpool Bathtubs, Water-Circulation Hydromassage Type:

a. Description: Packaged, enameled, cast-iron **OR** FRP **OR** PMMA **OR** porcelain-enameled, formed-steel, **as directed**, hydromassage bathtub with air-entrained-water jet nozzles and water circulation.

1) Seating Capacity: One **OR** Two, **as directed**, person(s).
2) Bathing Surface: Slip resistant.
3) Size: 60 by 30 inches (1525 by 765 mm) **OR** 66 by 30 inches (1680 by 765 mm) **OR** 60 by 42 inches (1525 by 1065 mm), **as directed**.
4) Base for Drop-in Unit: <**Insert description**> with access panel.
OR
Apron: Matching unit, covering exposed front and sides, and with access panel.
5) Color: White.
6) Drain Location: Left **OR** Right, **as directed**, end.
7) Controls: For pump, timer, **as directed**, and water heater, **as directed**.
8) Faucet: Fixture manufacturer's individual valves **OR** mixing valve, **as directed**, with over-rim tub filler.
9) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
10) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
11) Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and waste.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap and waste.
12) Water-Circulating System: Electric circulating pump and plastic piping.
13) Water Heater: Electric, inline, **as directed**.

2. Whirlpool Bathtubs, Airmassage Type:

a. Description: Packaged, PMMA airmassage bathtub with air-injection nozzles.

1) Seating Capacity: One **OR** Two, **as directed**, person(s).
2) Bathing Surface: Slip resistant.
3) Size: 60 by 30 inches (1525 by 765 mm) **OR** 66 by 30 inches (1680 by 765 mm) **OR** **OR** 60 by 42 inches (1525 by 1065 mm), **as directed**.
4) Base for Drop-in Unit: <**Insert description**> with access panel.
OR
Apron: Matching unit, covering exposed front and sides, and with access panel.
5) Color: White.
6) Drain Location: Left **OR** Right, **as directed**, end.
7) Controls: For blower, timer, **as directed**, and water heater, **as directed**.
8) Faucet: Fixture manufacturer's individual valves **OR** mixing valve, **as directed**, with over-rim tub filler.
9) Supplies: NPS 1/2 (DN 15) copper tubing with ball, gate, or globe valves.
10) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
11) Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and waste.
OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap and waste.

12) Air-Injection System: Electric, blower **OR** combination blower/heater, **as directed**, and plastic piping.

AA. Kitchen Sinks

1. Kitchen Sinks:

a. Description: One-bowl **OR** Two-bowl **OR** Three-bowl, **as directed**, residential, counter-mounting, enameled, cast-iron **OR** PMMA **OR** porcelain-enameled, formed-steel **OR** solid-surface **OR** stainless-steel, **as directed**, kitchen sink.

1) Metal Thickness: 0.038 inch (1.0 mm) **OR** 0.050 inch (1.3 mm), **as directed**.

2) Bowl (single bowl):

a) Drain: 3-1/2-inch (89-mm) crumb cup **OR** grid **OR** grid with offset waste **OR** outlet for disposer, **as directed**.

i. Location: Centered in bowl **OR** Near back of bowl, **as directed**.

3) Left Bowl:

a) Drain: 3-1/2-inch (89-mm) crumb cup **OR** grid **OR** grid with offset waste **OR** outlet for disposer, **as directed**.

i. Location: Centered in bowl **OR** Near back of bowl, **as directed**.

4) Right Bowl:

a) Drain: 3-1/2-inch (89-mm) crumb cup **OR** grid **OR** grid with offset waste **OR** outlet for disposer, **as directed**.

i. Location: Centered in bowl **OR** Near back of bowl, **as directed**.

5) Center Bowl:

a) Drain: 1-1/2-inch (38-mm) **OR** 3-1/2-inch (89-mm), **as directed**, crumb cup **OR** grid **OR** grid with offset waste, **as directed**.

i. Location: Centered in bowl.

6) Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.

7) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; continuous waste, **as directed**; and wall escutcheon(s).

OR

Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; continuous waste, **as directed**; and wall escutcheon(s).

8) Disposer: Not required.

9) Dishwasher Air-Gap Fitting: Required **OR** Not required, **as directed**.

10) Hot-Water Dispenser: Not required.

2. Bar Sinks:

a. Description: Single-bowl, residential, counter-mounting, enameled, cast-iron **OR** PMMA **OR** stainless-steel **OR** porcelain-enameled, cast-iron **OR** solid-surface, **as directed**, bar sink.

1) Supplies: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, chrome-plated copper with stops.

2) Drain: 1-1/2-inch (38-mm) **OR** 3-1/2-inch (89-mm), **as directed**, crumb cup **OR** grid **OR** grid with offset waste, **as directed**.

3) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.

OR

Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; and wall escutcheon.

4) Protective Shielding Guard(s): **As directed.**

BB. Service Sinks

1. Service Sinks, Standard Type:

a. Description: Trap-standard- and wall-mounting, enameled, cast-iron fixture with roll-rim **OR** vitreous-china fixture, **as directed**, with plain **OR** two faucet holes in, **as directed**, back and rim guard on front and sides.

1) Size (cast-iron fixture): 22 by 18 inches (560 by 460 mm) **OR** 24 by 20 inches (610 by 510 mm), **as directed**.
2) Size (vitreous-china fixture): 19 by 16 inches (480 by 405 mm) **OR** 22 by 20 inches (560 by 510 mm), **as directed**.
3) Color: White.
4) Faucet: Sink type. Polished OR rough, as directed, chrome-plated, solid-brass faucet. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook. Provide type with wall brace if faucet will be mounted above back.
5) Drain: Grid with NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.
6) Trap Standard: NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, enameled, cast iron with cleanout and floor flange.
7) Fixture Support: Sink.

2. Service Sinks, Floor-Mounting Type:
   a. Description: Floor-mounting, enameled, cast-iron fixture with front apron, raised back, and coated, wire rim guard. (This type of service sink requires a drainage piping trap under the fixture. This trap is not part of fixture fittings)
      1) Size: 28 by 28 inches (710 by 710 mm).
      2) Color: White.
      3) Faucet: Sink type. Polished OR rough, as directed, chrome-plated, solid-brass faucet with wall brace. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook..
      4) Drain: Grid with NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.

CC. Service Basins
1. Description: Flush-to-wall, floor-mounting, precast terrazzo **OR** cast-polymer, **as directed**, fixture with rim guard. (This type of fixture requires a drainage piping trap under the fixture. This trap is not part of fixture fittings.)
   a. Shape: Square **OR** Rectangular **OR** Five sided **OR** Radial front, **as directed**.
   b. Size: 24 by 24 inches (610 by 610 mm) **OR** 28 by 28 inches (710 by 710 mm) **OR** 24 by 36 inches (610 by 915 mm) **OR** 32 by 32 inches (815 by 815 mm) **OR** 36 by 36 inches (915 by 915 mm), **as directed**.
   c. Height: 6 inches (150 mm) **OR** 10 inches (255 mm) **OR** 12 inches (305 mm) **OR** 12 inches (305 mm) with dropped front, **as directed**.
   d. Tiling Flange: Not required **OR** On one side **OR** On two sides **OR** On three sides, **as directed**.
   e. Rim Guard: On front **OR** all, **as directed**, top surfaces.
   f. Color: Not applicable.
   g. Faucet: Sink type. Polished OR rough, as directed, chrome-plated, solid-brass faucet with wall brace. Include integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.
   h. Drain: Grid with NPS 2 (DN 50) **OR** NPS 3 (DN 80), **as directed**, outlet.

DD. Laundry Trays
1. Description: Stand-mounting **OR** Counter-mounting, **as directed**, enameled, cast-iron **OR** plastic, **as directed**, laundry trays.
   a. Size: 24 by 21 inches (610 by 535 mm) **OR** 25 by 22 inches (635 by 560 mm), **as directed**.
   b. Color: Not applicable.
   c. Faucet: Sink type, polished, chrome-plated, solid brass, for fixture-ledge **OR** wall **OR** counter, **as directed**, mounting.
   d. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops **OR** copper tubing with ball, gate, or globe valves, **as directed**.
   e. Drain: Grid with NPS 1-1/2 (DN 40) outlet.
   f. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular brass waste to wall; and wall escutcheon.

OR
Drain Piping: Schedule 40 ABS **OR** PVC, **as directed**, NPS 1-1/2 (DN 40) P-trap; tubular waste to wall; and wall escutcheon.

g. Stand: Not required **OR** Painted steel, **as directed**.

EE. Sacristy Sinks

1. Description: Two-bowl, counter-mounting, stainless-steel fixture.
   a. Size: Approximately 22 by 42 inches (560 by 1070 mm).
   b. Cover: Hinged with lock on left **OR** right, **as directed**, bowl.
   c. Supplies: NPS 1/2 (DN 15) chrome-plated copper with stops.
   d. Drains: One with stopper and one with grid.
   e. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, tubular-brass waste. Include one trap, one direct waste without trap, separate waste piping, and wall flanges.

1.3 EXECUTION

A. Installation

1. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
2. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   a. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   b. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   c. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
3. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
4. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
5. Install wall-mounting fixtures with tubular waste piping attached to supports.
6. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.
7. Install counter-mounting fixtures in and attached to casework.
8. Install fixtures level and plumb according to roughing-in drawings.
9. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   a. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
10. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
11. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
12. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
13. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.
14. Install toilet seats on water closets.
15. Install trap-seal liquid in dry urinals.
16. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
17. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
18. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
19. Install shower flow-control fittings with specified maximum flow rates in shower arms.
20. Install traps on fixture outlets.
    a. Exception: Omit trap on fixtures with integral traps.

b. Exception: Omit trap on indirect wastes, unless otherwise indicated.

21. Install disposer in outlet of each sink indicated to have disposer. Install switch where indicated or in wall adjacent to sink if location is not indicated.
22. Install dishwasher air-gap fitting at each sink indicated to have air-gap fitting. Install in sink deck **OR** on countertop at sink, **as directed**. Connect inlet hose to dishwasher and outlet hose to disposer.
23. Install hot-water dispensers in back top surface of sink or in countertop with spout over sink.
24. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 15 Section "Common Work Results For Plumbing".
25. Set bathtubs, shower receptors, and service basins in leveling bed of cement grout. Grout is specified in Division 15 Section "Common Work Results For Plumbing".
26. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants".

B. Connections
1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
2. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
3. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
4. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
5. Install fresh batteries in sensor-operated mechanisms.

D. Adjusting
1. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
2. Operate and adjust disposers, hot-water dispensers, and controls. Replace damaged and malfunctioning units and controls.
3. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.
4. Replace washers and seals of leaking and dripping faucets and stops.
5. Install fresh batteries in sensor-operated mechanisms.

E. Cleaning
1. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   a. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   b. Remove sediment and debris from drains.
2. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

F. Protection
1. Provide protective covering for installed fixtures and fittings.

2. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15451

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SECTION 15451a - MEDICAL PLUMBING FIXTURES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for medical plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. This Section includes the following medical plumbing fixtures and related components:
   a. Faucets for lavatories, showers, and sinks.
   b. Laminar-flow, faucet-spout outlets.
   c. Flushometers.
   d. Toilet seats.
   e. Protective shielding guards.
   f. Fixture supports.
   g. Bedpan washers.
   h. Water closets.
   i. Lavatories.
   j. Individual showers.
   k. Patients' combination toilets.
   l. Clinical sinks.
   m. Plaster sinks.
   n. Surgeons' scrub sinks.
   o. Surgeons' instrument sinks.
   p. Bathing units.
   q. Sitz baths.
   r. Bedpan washing equipment.
   s. Hydrotherapy whirlpools.
   t. Outlet boxes.
   u. Morgue equipment.

C. Definitions

1. Accessible Medical Plumbing Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
2. Fitting: Device that controls the flow of water into or out of the medical plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads, drains and tailpieces, and traps and waste pipes.
3. FRP: Fiberglass-reinforced plastic.
4. PMMA: Polymethyl methacrylate (acrylic) plastic.

D. Submittals

1. Product Data: For each type of medical plumbing fixture indicated.
2. LEED Submittal:
   a. Product Data for Credit WE 2, 3.1, and 3.2: Documentation indicating flow and water consumption requirements.
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act", **as directed**; for plumbing fixtures for people with disabilities.
3. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
4. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
5. Select combinations fixtures and trim, faucets, fittings, and other components that are compatible.
6. Comply with the following applicable standards and other requirements specified for medical plumbing fixtures:
   a. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
   b. Plastic Bathtubs: ANSI Z124.1.
   c. Plastic Shower Enclosures: ANSI Z124.2.
   d. Slip-Resistant Bathing Surfaces: ASTM F 462.
   e. Vitreous-China Fixtures: ASME A112.19.2M.
7. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
   a. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
   b. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
   c. Faucets: ASME A112.18.1.
   d. Hose-Connection Vacuum Breakers: ASSE 1011.
   e. Hose-Coupling Threads: ASME B1.20.7.
   f. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
   g. NSF Materials: NSF 61.
   h. Pipe Threads: ASME B1.20.1.
   i. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   j. Supply Fittings: ASME A112.18.1.
   k. Brass Waste Fittings: ASME A112.18.2.
8. Comply with the following applicable standards and other requirements specified for bathtub and shower faucets:
   a. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
   b. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
   c. Faucets: ASME A112.18.1.
   d. Hand-Held Showers: ASSE 1014.
   e. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
   f. Hose-Coupling Threads: ASME B1.20.7.
   g. Manual-Control Antiscald Faucets: ASTM F 444.
   h. Pipe Threads: ASME B1.20.1.
   i. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
   j. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
   k. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
9. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
   a. Atmospheric Vacuum Breakers: ASSE 1001.
   b. Brass and Copper Supplies: ASME A112.18.1.
   c. Flexible Water Connectors: ASME A112.18.6.
   d. Manual-Operation Flushometers: ASSE 1037.
   e. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
   f. Brass Waste Fittings: ASME A112.18.2.
10. Comply with the following applicable standards and other requirements specified for miscellaneous components:

a. Grab Bars: ASTM F 446.
b. Hose-Coupling Threads: ASME B1.20.7.
c. Off-Floor Fixture Supports: ASME A112.6.1M.
d. Pipe Threads: ASME B1.20.1.
e. Plastic Toilet Seats: ANSI Z124.5.
f. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.2 PRODUCTS

A. Lavatory Faucets
1. Description: Faucet for lavatory-type medical plumbing fixture. Coordinate faucet inlets with supplies, connectors, and fixture holes; coordinate outlet with spout and fixture receptor.
a. Maximum Flow Rate: 2.2 gpm (8.3 L/min.).
b. Body Material: Solid brass.
c. Finish: Polished chrome plate.
d. Type: Single-control mixing **OR** Single-valve nonmixing **OR** Two-handle mixing, **as directed**.
e. Tempering System: Not required **OR** Thermostatic **OR** Pressure balance, **as directed**.
f. Supply Centers: Single hole **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** 12 inches (305 mm) **OR** Adjustable, **as directed**.
g. Mounting: Deck, exposed **OR** Deck, concealed **OR** Back/wall, exposed **OR** Back/wall, concealed, **as directed**.
h. Handle(s): Single lever **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Not applicable, **as directed**.
i. Temperature Indicators: Color-coded for hot and cold water.
j. Inlet(s): NPS 3/8 (DN 10) tubing, plain end **OR** NPS 3/8 (DN 10) tubing, with NPS 1/2 (DN 15) male adaptor **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
k. Spout: Rigid **OR** Swing **OR** Rigid gooseneck **OR** Swivel gooseneck, **as directed**, brass.
l. Spout Outlet: Aerator **OR** Spray **OR** Laminar flow **OR** Plain end **OR** Spray, 0.5 gpm (1.5 L/min.), **as directed**.
m. Operation: Compression, manual **OR** Noncompression, manual **OR** Automatic, hard-wired electric sensor, **as directed**.
n. Drain: Pop up **OR** See fixture, **as directed**.

B. Shower Faucets
1. Description: Faucet for shower-type medical plumbing fixtures. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies.
a. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
b. Body Material: Solid brass.
c. Finish: Polished chrome plate.
d. Type: Thermostatic **OR** Pressure balance **OR** Thermostatic and pressure balance, **as directed**, with integral or field-installed check stops on hot- and cold-water supplies.
e. Mounting: Exposed **OR** Concealed, **as directed**.
f. Handle(s): Single lever **OR** Cross, four arm **OR** Not applicable, **as directed**.
g. Temperature Indicators: Color-coded for hot and cold water.
h. Diverter Valve: Not required **OR** Integral with mixing valve **OR** Not integral with mixing valve, **as directed**.
i. Backflow Protection Device for Hand-Held Shower: Required **OR** Not required, **as directed**.
j. Operation: Compression, manual **OR** Noncompression, manual **OR** Automatic, hard-wired electric sensor, **as directed**.
k. Antiscald Device: Integral with mixing valve **OR** Not required, **as directed**.

l. Supply Connections: NPS 1/2 (DN 15) **OR** NPS 1/2 (DN 15), union **OR** Sweat, **as directed**.
m. Shower Head Material: Brass with chrome-plated finish.
n. Head Type: Ball joint **OR** Without ball joint **OR** Hand held, slide-bar mounted **OR** Hand held, hook mounted, **as directed**.
o. Spray Pattern: Fixed **OR** Adjustable, **as directed**.
p. Integral Volume Control: Required **OR** Not required, **as directed**.
q. Shower-Arm, Flow-Control Fitting: Not required **OR** 1.5 gpm (5.7 L/min.) **OR** 2.0 gpm (7.6 L/min.), **as directed**.

C. Sink Faucets
1. Description: Faucet for sink-type medical plumbing fixtures. Coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor.
a. Maximum Flow Rate: 2.5 gpm (9.5 L/min.), unless otherwise indicated.
b. Body Material: Solid brass.
c. Finish: Polished chrome plate **OR** Rough chrome plate, **as directed**.
d. Type: Sink faucet **OR** Clinical-sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook, **as directed**.
e. Tempering Device: Thermostatic **OR** Pressure balance **OR** Not required, **as directed**.
f. Mixing Valve: Single control **OR** Two-lever handle, **as directed**.
g. Backflow Protection Device for Hose Outlet: Required **OR** Not required **OR** Not applicable, **as directed**.
h. Supply Centers: Single hole **OR** 4 inches (102 mm) **OR** 6 inches (152 mm) **OR** 8 inches (203 mm) **OR** Adjustable, **as directed**.
i. Mounting: Deck, exposed **OR** Deck, concealed **OR** Back/wall, exposed **OR** Back/wall, concealed, **as directed**.
j. Handle(s): Lever **OR** Knob **OR** Cross, four arm **OR** Wrist blade, 4 inches (102 mm) **OR** Elbow, 6 inches (152 mm) **OR** Not applicable, **as directed**.
k. Temperature Indicators: Color-coded for hot water on left and cold water on right.
l. Inlet(s): NPS 3/8 (DN 10) plain-end tubing **OR** NPS 3/8 (DN 10) tubing with NPS 1/2 (DN 15) male adapter **OR** NPS 1/2 (DN 15) male shank **OR** NPS 1/2 (DN 15) female shank, **as directed**.
m. Spout: Rigid, solid **OR** Swing tubular **OR** Rigid, gooseneck, solid **OR** Swivel, gooseneck, solid, **as directed**, brass with wall brace, **as directed**.
n. Spout Outlet: Aerator **OR** Swivel aerator/spray **OR** Spray **OR** Laminar flow **OR** Hose thread **OR** Plain end, **as directed**.
o. Vacuum Breaker: Required **OR** Not required, **as directed**.
p. Operation: Compression, manual **OR** Noncompression, manual **OR** Automatic, hard-wired electric sensor, **as directed**.

D. Laminar-Flow Faucet-Spout Outlets
1. Description: Chrome-plated-brass faucet-spout outlet that produces non-aerating laminar stream. Include male or female thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

E. Flushometers
1. Description: Flushometer for clinical-sink-type **OR** water-closet-type, **as directed**, medical plumbing fixture. Include brass body with corrosion-resistant internal components, non-hold-open feature, **as directed**, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
a. Internal Design: Diaphragm operation.
b. Style: Exposed **OR** Concealed, **as directed**.
c. Inlet Size: NPS 1 (DN 25).
d. Trip Mechanism: Oscillating, lever-handle actuator **OR** Mechanical, push-button actuator with stainless-steel access plate **OR** Hydraulic, push-button actuator **OR** Foot-pedal

actuator **OR** Hard-wired, electric-sensor actuator **OR** Battery-operated sensor actuator, **as directed**.

e. Consumption: 1.6 gal./flush (6.0 L/flush) **OR** 3.5 gal./flush (13.3 L/flush), **as directed**.

f. Tailpiece Size: NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, and standard length to top of bowl.

g. Integral Bedpan Washer: Not required **OR** Factory fabricated, attached to tailpiece, and with spray head, **as directed**.

F. Toilet Seats

1. Description: Plastic toilet seat for water-closet-type medical plumbing fixture.
   a. Material: Molded, solid plastic with antimicrobial agent, **as directed**.
   b. Configuration: Closed **OR** Open, **as directed**, front with **OR** without, **as directed**, cover.
   c. Size: Elongated, unless otherwise indicated.
   d. Class: Standard **OR** Heavy-duty, **as directed**, commercial.
   e. Hinge Type: Stainless-steel CK, check **OR** SC, self-sustaining check, **as directed**.
   f. Color: White **OR** Black, **as directed**.

G. Protective Shielding Guards

1. Protective Shielding Pipe Covers:
   a. Description: Manufactured plastic wraps for covering medical plumbing fixture hot-water supply **OR** hot- and cold-water supplies, **as directed**, and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
2. Protective Shielding Piping Enclosures:
   a. Description: Manufactured plastic enclosure for covering medical plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

H. Fixture Supports

1. Water-Closet Supports:
   a. Description: Combination carrier designed for accessible **OR** standard, **as directed**, mounting height of wall-mounting, water-closet-type medical plumbing fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
2. Lavatory Supports:
   a. Description: Type I, lavatory carrier with exposed arms and tie rods **OR** Type II, lavatory carrier with concealed arms and tie rod **OR** Type III, lavatory carrier with hanger plate and tie rod, **as directed**, for wall-mounting, lavatory-type medical plumbing fixture. Include steel uprights with feet.
   b. Accessible-Fixture Support: Include rectangular steel uprights.
3. Sink Supports:
   a. Description: Type I, sink carrier with exposed arms and tie rods **OR** Type II, sink carrier with hanger plate, bearing studs, and tie rod **OR** Type III, sink carrier with hanger plate and exposed arms, **as directed**, for sink-type medical plumbing fixture. Include steel uprights with feet.
4. Bedpan Washers
   a. Description: Wall-mounting, hand-held, hand-control **OR** single-pedal, foot-control **OR** double-pedal, hot- and cold-water control, **as directed**, medical plumbing fixture.
      1) Hose: 48-inch- (1220-mm-) long rubber or vinyl hose with spray nozzle, wall bracket, and hook.
      2) Self-closing valve.
      3) Loose-key supply stop.
      4) Vacuum Breaker: Wall mounting, atmospheric.
      5) Finish: Polished, chrome-plated finish on metal parts exposed after installation.

I. Water Closets

1. Wall-Mounting Water Closets:
   a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, back-outlet, vitreous-china medical plumbing fixture designed for bedpan washing and flushometer valve operation.
      1) Style: Flushometer valve.
         a) Bowl Type: Elongated with siphon-jet design and bedpan lugs or slots.
         b) Design Consumption: 1.6 gal./flush (6 L/flush).
         c) Color: White.
2. Floor-Mounting Water Closets:
   a. Description: Accessible, floor-mounting **OR** Floor-mounting, **as directed**, floor-outlet, vitreous-china medical plumbing fixture designed for bedpan washing and flushometer valve operation.
      1) Style: Flushometer valve.
         a) Bowl Type: Elongated with siphon-jet design and bedpan lugs or slots. Include bolt caps matching fixture.
         b) Height: Standard **OR** Accessible, **as directed**.
         c) Design Consumption: 1.6 gal./flush (6 L/flush).
         d) Color: White.

J. Lavatories
1. Wall-Mounting Lavatories:
   a. Description: Accessible, wall-mounting **OR** Wall-mounting, **as directed**, vitreous-china medical plumbing fixture.
      1) Type: With back **OR** Ledge back **OR** Shelf back **OR** Slab, **as directed**.
      2) Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**, rectangular.
      3) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.
      4) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
      5) Color: White.
      6) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
      7) Supplies: NPS 3/8 (DN 10) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
      8) Drain: See faucet **OR** Grid **OR** Grid with offset, **as directed**.
         a) Location: Not applicable.
      9) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
      10) Protective Shielding Guard(s): Designation, as directed by the Owner.
      11) Fixture Support: Lavatory.
2. Counter-Mounting Lavatories:
   a. Description: Accessible, **as directed**, Counter-mounting **OR** Undercounter-mounting, **as directed**, vitreous-china, medical plumbing fixture.
      1) Type: Flat rim with ledge **OR** Self-rimming, **as directed**.
      2) Rectangular Lavatory Size: 18 by 15 inches (457 by 381 mm) **OR** 19 by 16 inches (483 by 406 mm) **OR** 20 by 18 inches (508 by 457 mm) **OR** 24 by 20 inches (610 by 508 mm), **as directed**.
      3) Oval Lavatory Size: 19 by 16 inches (483 by 406 mm) **OR** 20 by 17 inches (508 by 432 mm), **as directed**.
      4) Round Lavatory Size: 18 inches (457 mm) **OR** 19 inches (483 mm), **as directed**, in diameter.
      5) Faucet Hole Punching: One hole **OR** Three holes, 2-inch (51-mm) centers **OR** Three holes, 4-inch (102-mm) centers, **as directed**.

6) Faucet Hole Location: Top **OR** Front wall **OR** Inclined panel, **as directed**.
7) Color: White.
8) Faucet: Lavatory with pop-up waste **OR** for separate drain, **as directed**.
9) Supplies: NPS 3/8 (DN 10) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
10) Drain: See faucet **OR** Grid **OR** Grid with offset, **as directed**.
    a) Location: Not applicable.
11) Drain Piping: NPS 1-1/4 (DN 32) **OR** NPS 1-1/4 by NPS 1-1/2 (DN 32 by DN 40), **as directed**, chrome-plated, cast-brass P-trap; NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, 0.032-inch- (0.8-mm-) **OR** 0.045-inch- (1.1-mm-), **as directed**, thick tubular brass waste to wall; and wall escutcheon.
12) Protective Shielding Guard(s): Designation, as directed by the Owner.

K. Individual Showers:
1. Description: Accessible, **as directed**, FRP **OR** PMMA, **as directed**, shower enclosure medical plumbing fixture with slip-resistant bathing surface complying with ASTM F 462. Comply with ADA requirements for use by people with disabilities.
   a. Size: 36 by 34 inches (915 by 865 mm) **OR** 42 by 36 inches (1065 by 915 mm) **OR** 43 by 39 inches (1090 by 990 mm) **OR** 48 by 34 inches (1220 by 865 mm) **OR** 52 by 36 inches (1320 by 915 mm) **OR** 60 by 36 inches (1525 by 915 mm) **OR** 72 by 36 inches (1830 by 915 mm), **as directed**.
   b. Surround: One piece.
   c. Color: White.
   d. Faucet: Shower.
   e. Drain: Grid, NPS 2 (DN 50).
      1) Location: Left side **OR** Center **OR** Right side, **as directed**.
   f. Accessories: If not furnished as integral components of specified fixture. Accessories are specified in Division 10 Section "Toilet And Bath Accessories".
      1) Grab bar(s).
      2) Normal-duty **OR** Heavy-duty, **as directed**, shower-curtain rod.
      3) Vinyl **OR** Duck **OR** Antibacterial, **as directed**, shower curtain.
      4) Shower-curtain hooks.
      5) Folding seat, **as directed**.

L. Patients' Combination Toilets
1. Swing-Away, Patients' Combination Toilets:
   a. Description: Factory-fabricated, combination water closet and lavatory medical plumbing fixture.
      1) Cabinet: Fixed installation with storage space and toilet paper holder.
         a) Material: Stainless steel **OR** Stainless steel, plastic laminate, or fiberglass, **as directed**, with laminated-wood or -plastic **OR** solid-plastic **OR** stainless-steel, **as directed**, top surface.
         b) Color: Not applicable.
         c) Mounting: Wall bracket.
      2) Water Closet: Swivel, floor-mounting, back-outlet **OR** floor-outlet, **as directed**, flushometer valve design.
         a) Material: Stainless steel.
         b) Orientation: Left **OR** Right, **as directed**, hand.
         c) Color: Not applicable.
         d) Toilet Seat: White, solid plastic.
         e) Flushometer: Concealed flushometer valve with push-button trip mechanism, check stop, and vacuum breaker on tailpiece.
         f) Fixture Support: Floor plate.
         g) Seal: For outlet.
      3) Lavatory: Counter mounting.
         a) Material: Stainless steel.

b) Color: Not applicable.
c) Faucet: Gooseneck type with wrist-blade handles **OR** Swing-spout type with single lever, **as directed**.
d) Drain: Grid, NPS 1-1/4 (DN 32).
e) Drain Piping: NPS 1-1/4 (DN 32) chrome-plated, cast-brass P-trap; tubular-brass waste to wall; and wall flange.

4) Bedpan Washer: On flushometer valve tailpiece or separate attachment affixed to unit.

2. Static, Patients' Combination Toilets:

a. Description: Factory-fabricated, combination water closet and lavatory fixture.

1) Cabinet: Fixed installation; swing-away cabinet or retractable, water-closet cover design with storage space and toilet paper holder.

a) Material: Stainless steel **OR** Stainless steel, plastic laminate, or fiberglass, **as directed**, with laminated-wood or -plastic **OR** solid-plastic **OR** stainless-steel, **as directed**, top surface.
b) Color: Not applicable.
c) Mounting: Wall bracket.

2) Water Closet: Floor-mounting, floor-outlet, flushometer valve design.

a) Material: Stainless steel or vitreous china.
b) Orientation: Left **OR** Right, **as directed**, hand.
c) Color: Not applicable.
d) Toilet Seat: White, solid plastic.
e) Flushometer: Concealed flushometer valve with push-button trip mechanism, check stop, and vacuum breaker on tailpiece.
f) Seal: For outlet.

3) Lavatory: Counter mounting.

a) Material: Stainless steel.
b) Color: Not applicable.
c) Faucet: Gooseneck type with wrist-blade handles **OR** Swing-spout type with single lever, **as directed**.
d) Drain: Grid, NPS 1-1/4 (DN 32).
e) Drain Piping: NPS 1-1/4 (DN 32) chrome-plated, cast-brass P-trap; tubular-brass waste to wall; and wall flange.

4) Bedpan Washer: On flushometer valve tailpiece or separate attachment affixed to unit.

M. Clinical Sinks

1. Wall-Mounting Clinical Sinks:

a. Description: Wall-mounting, back-outlet, vitreous-china, flushing-rim, service-sink-type medical plumbing fixture.

1) Size: Approximately 25 by 20 inches (635 by 510 mm).
2) Color: White.
3) Rim Guard: Stainless steel on front and also on sides if flat rim.
4) Faucet: Sink, polished, chrome-plated, solid-brass, service-sink faucet type, including integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.

2. Floor-Mounting Clinical Sinks:

a. Description: Floor-mounting, bottom-outlet, vitreous-china, flushing-rim, service-sink-type medical plumbing fixture. Include bolt caps.

1) Size: Approximately 27 by 20 inches (685 by 510 mm).
2) Color: White.
3) Rim Guards: Stainless steel on front and sides.
4) Sink Base: 10-inch (25.4-mm) -high, cast terrazzo if required.

5) Faucet: Sink, polished, chrome-plated, solid-brass, service-sink faucet type, including integral stops in shanks, vacuum breaker, hose-thread outlet, and pail hook.

N. Plaster Sinks:
1. Description: Wall-mounting, vitreous-china medical plumbing fixture.
   a. Size: 24 by 22 inches (610 by 560 mm) **OR** 30 by 22 inches (760 by 560 mm), **as directed**, with back or ledge faucet holes.
   b. Color: White.
   c. Faucet Holes: One **OR** Two, **as directed**, in back or ledge.
   d. Faucet: Sink.
   e. Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
   f. Drain: Grid, NPS 1-1/2 (DN 40) with NPS 1-1/2 (DN 40) to NPS 2 (DN 50) adaptor, **as directed**.
   g. Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, chrome-plated brass; 0.045-inch- (1.1-mm-) thick waste to interceptor; interceptor to wall; and wall flange.
   h. Plaster Interceptor:
      1) Description: Cast-iron or steel body and removable cover with acid-resistant-enameled interior lining and outside coating; removable, corrosion-resistant metal screens or strainer; and NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, inlet and outlet.
2. Fixture Support: Sink with white-enameled-steel brackets.

O. Surgeons' Scrub Sinks
1. Stainless-Steel Surgeons' Scrub Sinks:
   a. Description: Wall-mounting, sink-type medical plumbing fixture.
      1) Size: Approximately 31 by 20 inches (790 by 510 mm) with back with 1 faucet hole.
      2) Faucet: Chrome-plated-brass, gooseneck type matching fixture.
      3) Operation: Foot-pedal **OR** Knee **OR** Automatic, hard-wired electric sensor, **as directed**, control.
      4) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
      5) Drain: Grid, NPS 1-1/2 (DN 40).
      6) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
      7) Fixture Support: Sink.
2. Vitreous-China Surgeons' Scrub Sinks:
   a. Description: Wall-mounting, sink-type medical plumbing fixture.
      1) Size: 28 by 22 inches (710 by 560 mm) **OR** 30 by 22 inches (760 by 560 mm), **as directed**, with back or ledge with 1 faucet hole.
      2) Color: White.
      3) Faucet: Chrome-plated-brass, gooseneck-type matching fixture.
      4) Operation: Foot-pedal **OR** Knee, **as directed**, control.
      5) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
      6) Drain: Grid, NPS 1-1/2 (DN 40).
      7) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
      8) Fixture Support: Sink.

P. Surgeons' Instrument Sinks:
1. Description: Wall-mounting, stainless-steel, sink-type medical plumbing fixture. Include instrument tray on each side.
   a. Size: 28 by 20 inches (710 by 510 mm) with 1 hole for deck-mounting faucet.

b. Faucet: Chrome-plated-brass, gooseneck type matching fixture with knee **OR** foot-pedal, **as directed**, control for mixing hot- and cold-water supplies.
c. Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops.
d. Drain: Grid, NPS 1-1/2 (DN 40).
e. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
f. Fixture Support: Sink.

Q. Bathing Units
1. Institutional Bath Tubs:
a. Description: Enameled, cast-iron, island medical plumbing fixture with separate wall-mounting faucet.
1) Size: 66 by 30 by 18 inches (1680 by 765 by 455 mm).
2) Base: Enameled, cast iron to raise rim of bathtub to 28 inches (710 mm) above the floor.
3) Faucet: Shower **OR** Sink, **as directed**, modified to include tub filler spout.
4) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops. Include atmospheric vacuum breaker.
5) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
6) Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; 0.045-inch- (1.1-mm-) thick tubular-brass waste to wall; and wall flange.
2. Bathing Units:
a. Description: Plastic-tub, institutional side-entry bath **OR** whirlpool-bath, **as directed**, fixture with integral controls.
1) Tub Size: 60 by 30 inches (1525 by 765 mm).
2) Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.
3) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves.
4) Drain: NPS 1-1/2 (DN 40) and NPS 2 (DN 50).
5) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, cast-brass P-trap, waste to wall, and wall flange. Include combined drain piping if two drains.
3. Bathing Units:
a. Description: Plastic-tub, institutional side-entry **OR** transfer-lift-entry **OR** slide-on-entry, **as directed**, adjustable-height **OR** fixed-height, **as directed**, bath fixture with integral controls.
1) Tub Size: 60 by 30 inches (1525 by 765 mm).
2) Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.
3) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves.
4) Drain: NPS 1-1/2 (DN 40) and NPS 2 (DN 50).
5) Drain Piping: NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, cast-brass P-trap, waste to wall, and wall flange. Include combined drain piping if two drains.
6) Lift System: Not required.
4. Bathing Units:
a. Description: Plastic-tub, institutional front-entry shower fixture with integral controls.
1) Cabinet Size: 35 by 41 inches (889 by 1041 mm).
2) Controls: Vacuum breakers on supplies, thermostatic mixing valve, tub fill spout, and hand-held shower head.
3) Supplies: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25), **as directed**, copper tubing with ball, gate, or globe valves.
4) Drain: NPS 2 (DN 50).
5) Drain Piping: NPS 2 (DN 50) cast-brass P-trap, waste to wall, and wall flange.

5. Residential Bath Tubs:
   a. Description: Plastic island or against-wall-installation, **as directed**, medical plumbing fixture with side door, seat, and separate wall-mounting faucet.
      1) Size 1
         a) Size: Approximately 60 by 32 by 21 inches (1525 by 815 by 535 mm).
         b) Seat: Integral.
         c) Drain Location: Left **OR** Right, **as directed**, end.
      2) Size 2
         a) Size: Approximately 60 by 42 by 24.5 inches (1525 by 1070 by 620 mm).
         b) Seat: Integral bench **OR** None, **as directed**.
         c) Drain Location: Right end.
      3) Material: PMMA.
      4) Skirt: Front only **OR** Full, on three sides, **as directed**.
      5) Door: Side opening with rubber sealing gasket.
      6) Faucet: Shower **OR** Sink, **as directed**, modified to include tub filler spout.
      7) Supplies: NPS 1/2 (DN 15) chrome-plated copper tubes or flexible connectors, **as directed**, with stops. Include atmospheric vacuum breaker.
      8) Drain: NPS 1-1/2 (DN 40); chrome-plated exposed parts; brass pop-up waste and overflow.
      9) Drain Piping: NPS 1-1/2 (DN 40) cast-brass P-trap and 0.045-inch- (1.1-mm-) thick, tubular-brass waste to wall.

R. Sitz Baths:
   1. Description: Pedestal-mounting **OR** Wall-mounting, **as directed**, vitreous-china, perineal bath medical plumbing fixture.
      a. Color: White.
      b. Drain: NPS 1-1/2 (DN 40) with removable overflow attachment.
      c. Drain Piping: NPS 1-1/2 (DN 40) chrome-plated, cast-brass P-trap; waste to wall; and wall flange.
      d. Fixture Support: Sink.
      e. Faucet:
         1) Description: Wall-mounting, single-lever-handle, thermostatic-mixing-valve faucet with concealed supplies and wall-mounting thermometer.
            a) Material: Brass body and escutcheon.
            b) Flow Rate: Modified to 1.5 gpm (5.7 L/min.) maximum, unless otherwise indicated.
            c) Finish: Polished chrome plate.
            d) Temperature Indicators: Color-coded for hot and cold water.
      f. Exposed Piping: Chrome-plated; brass pipe or copper tube.

S. Bedpan Washing Equipment
   1. Bedpan Washers/Sanitizers:
      a. Description: Recessed-mounting **OR** On-wall-mounting **OR** Pedestal-mounting, **as directed**, medical plumbing fixture for cleaning bedpans and urinals having cast-iron chamber and waste assembly with spray nozzles and enameled-steel **OR** stainless-steel, **as directed**, front panel and cover box.
         1) Controls: Electric, 120-V ac, automatic operation with timer, solenoid valves, and circuit breaker.
         2) Door Mechanism: Foot-pedal operation.
         3) Supplies: NPS 1 (DN 25) cold water and NPS 3/8 (DN 10) hot water **OR** steam, **as directed**.
         4) Drain: NPS 3 (DN 80) P-trap and soil pipe.
         5) Atmospheric Vent: NPS 2 (DN 50).
         6) Mounting Hardware: Matching fixture mounting arrangement.
         7) Accessories:
            a) Bedpan Rack(s): One **OR** Two, **as directed**.

b) Urinal Rack(s): One **OR** Two, **as directed**.
c) Drain Tray(s): One **OR** Two, **as directed**.

2. Bedpan Washers/Disinfectors:
   a. Description: Freestanding-mounting **OR** On-wall-mounting **OR** Undercounter-mounting, **as directed**, medical plumbing fixture for cleaning bedpans and urinals; with steam generator, pump, and spray nozzle.
      1) Controls: Electric, automatic operation.
      2) Cabinet: Stainless steel.
      3) Wash Chamber: Stainless steel.
      4) Supplies: NPS 1/2 (DN 15) cold water and NPS 1/2 (DN 15) hot water.
      5) Drain: NPS 4 (DN 100) P-trap and soil pipe.
      6) Mounting Hardware: Matching fixture mounting arrangement.

T. Hydrotherapy Whirlpools
1. Podiatry Whirlpools:
   a. Description: Stationary, stainless-steel tank for feet and ankles.
      1) Water Capacity: 15 gal. (57 L).
      2) Drain: Waste connection.
      3) Controls.
      4) Thermometer: Control panel or tank mounted.
      5) One electric turbine ejector.
2. Upper-Extremity Whirlpools:
   a. Description: Stationary, pedestal-mounted, stainless-steel tank for arms, hands, and elbows.
      1) Water Capacity: 25 gal. (95 L).
      2) Drain: Waste connection.
      3) One arm support.
      4) Controls.
      5) Thermometer: Control panel or tank mounted.
      6) One electric turbine ejector.
3. High-Tank Body Whirlpools:
   a. Description: Stationary, stainless-steel tank for legs, hip, and back.
      1) Water Capacity: 105 gal. (397 L).
      2) Drain: Waste connection.
      3) Controls.
      4) Thermometer: Control panel or tank mounted.
      5) One electric turbine ejector.
4. Low-Tank Body Whirlpools:
   a. Description: Stationary, extended-length stainless-steel tank for legs, hip, and lower back.
      1) Water Capacity: 105 gal. (397 L).
      2) Drain: Waste connection.
      3) Controls.
      4) Thermometer: Control panel or tank mounted.
      5) Head rest.
      6) One electric turbine ejector.
5. Small, Hubbard Immersion Tanks:
   a. Description: Stationary, butterfly-shaped tank, for full-body massage
      1) Tank Dimensions: 93 by 64 by 22 inches (2362 by 1626 by 560 mm).
      2) Overall Height: 34 to 38 inches (864 to 965 mm).
      3) Water Capacity: 268 gal. (1014 L).
      4) Material: Stainless steel.
      5) Supports: Legs or base.
      6) Controls.
      7) Thermometer: Control panel or tank rim mounted.
      8) Supply: Over-the-rim fill spout.

9) Drains: Two waste connections.
10) Electric Turbine Ejectors: Two; one rail mounted on each side.
11) Thermostatic, mixing-valve assembly.
12) Hose and hand-held shower.
13) Wash-out-hose assembly.
14) Stretcher lift.
15) Overhead electric, **as directed**, hoist.

6. Medium, Hubbard Immersion Tanks:
   a. Description: Stationary, butterfly-shaped tank, for full-body massage.
      1) Tank Dimensions: 100 by 73 by 24 inches (2540 by 1854 by 610 mm).
      2) Overall Height: 34 to 38 inches (864 to 965 mm).
      3) Water Capacity: 377 gal. (1468 L).
      4) Material: Stainless steel.
      5) Supports: Legs or base.
      6) Controls.
      7) Thermometer: Control panel or tank rim mounted.
      8) Supply: Over-the-rim fill spout.
      9) Drain: One waste connection.
      10) Electric Turbine Ejector: One, panel mounted.
      11) Thermostatic, mixing-valve assembly.
      12) Hose and hand-held shower.
      13) Wash-out-hose assembly.
      14) Stretcher lift.
      15) Overhead electric, **as directed**, hoist.
7. Large, Hubbard Immersion Tanks:
   a. Description: Stationary, butterfly-shaped tank, for full-body massage.
      1) Tank Dimensions: 106 by 77 by 22 inches (2692 by 1956 by 560 mm).
      2) Overall Height: 34 inches (864 mm).
      3) Water Capacity: 425 gal. (1609 L).
      4) Material: Stainless steel.
      5) Supports: Legs or base.
      6) Controls.
      7) Thermometer: Control panel or tank rim mounted.
      8) Supply: Over-the-rim fill spout.
      9) Drain(s): One or two waste connections.
      10) Electric Turbine Ejectors: Two; one rail mounted on each side.
      11) Thermostatic, mixing-valve assembly.
      12) Hose and hand-held shower.
      13) Wash-out-hose assembly.
      14) Stretcher lift.
      15) Overhead electric, **as directed**, hoist.
8. Full-Body Immersion Tanks:
   a. Description: Stationary, rectangular tank, for full-body massage
      1) Tank Dimensions: 90 by 32 by 19 inches (2286 by 813 by 483 mm) **OR** 95 by 41 by 22 inches (2413 by 1041 by 560 mm), **as directed**.
      2) Overall Height: 32 or 34 inches (813 or 860 mm).
      3) Water Capacity: 195 gal. (738 L) **OR** 260 gal. (984 L), **as directed**.
      4) Material: Stainless steel.
      5) Supports: Legs or base.
      6) Controls.
      7) Thermometer: Control panel or tank rim mounted.
      8) Supply: Over-the-rim fill spout.
      9) Drain(s): One or two waste connections.
      10) Electric Turbine Ejector: One, tank mounted at end **OR** on rail **OR** on side, **as directed**.
      11) Thermostatic, mixing-valve assembly.

12) Hose and hand-held shower.
13) Wash-out-hose assembly.
14) Stretcher lift.
15) Overhead electric, **as directed**, hoist.

U. Outlet Boxes
1. Dialysis Equipment Outlet Boxes:
a. Description: Recessed-mounting outlet box with water supply and drain connections.
1) Box and Faceplate: Stainless steel.
2) Supply Fitting(s): 1 **OR** 2, **as directed**, NPS 1/2 (DN 15) PVC ball valve(s) and adapter with male hose-thread outlet.
3) Drain: NPS 2 (DN 50) standpipe, P-trap, and direct waste connection to drainage piping.
b. Reinforcement: 2-by-4-inch (50-by-100-mm) fire-retardant-treated-wood blocking between studs. Fire-retardant-treated wood blocking is specified in Division 06 Section "Rough Carpentry".

V. Morgue Equipment
1. Autopsy Tables:
a. Description: Pedestal stainless-steel table with sink; designed for downdraft ventilation.
1) Material: Stainless steel.
2) Overall Size: Approximately 88 by 30 inches (2250 by 760 mm) with deck faucet holes.
3) Faucet: Deck mounted with wrist- or elbow-blade handles.
4) Aspirator: Deck mounted.
5) Removable body supports.
6) Rinse Assembly: Deck-mounted faucet with hose.
7) Disposer: Not required **OR** Required, **as directed**.
8) Fixture Support: Sink.
9) Receptacle: Duplex, hospital grade with ground-fault interruption.
10) Supplies: Chrome-plated copper tubes or flexible connectors, **as directed**, with atmospheric vacuum breakers and stops.
11) Drain: Chrome-plated, cast-brass P-trap and waste to wall.
2. Dissecting Sinks:
a. Description: Wall-mounting sink with backsplash.
1) Material: Stainless steel.
2) Overall Size: 84 by 28 inches (2134 by 711 mm) with back faucet holes.
3) Sink Size: Approximately 30 inches (763 mm) wide.
4) Equipment drawer.
5) Faucet: Back mounted with wrist- or elbow-blade handles.
6) Aspirator: Back mounted.
7) Rinse Assembly: One back-mounted faucet with hose.
8) Disposer: Not required **OR** Required, **as directed**.
9) Fixture Support: Sink.
10) Supplies: Chrome-plated copper tubes or flexible connectors, **as directed**, with atmospheric vacuum breakers and stops.
11) Drain: Chrome-plated, cast-brass P-trap and waste to wall.
12) Back-mounted, hand-held-type eye wash.

1.3 EXECUTION

A. Installation
1. Assemble medical plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

2. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   a. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   b. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   c. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
3. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
4. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
5. Install wall-mounting fixtures with tubular waste piping attached to supports.
6. Install counter-mounting fixtures in and attached to casework.
7. Install fixtures level and plumb according to roughing-in drawings.
8. Install water-supply piping with stop on each supply to each fixture to be connected to domestic water piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   a. Exception: Use ball, gate, or globe valve if stops are not specified with fixture. Valves are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
9. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
10. Install flushometer valves for accessible water closets with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
11. Install toilet seats on water closets.
12. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
13. Install shower flow-control fittings with specified maximum flow rates in shower arms.
14. Install traps on fixture outlets.
    a. Exception: Omit trap on fixtures with integral traps.
15. Install escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 15 Section "Common Work Results For Plumbing".
16. Set showers in leveling bed of cement grout. Grout is specified in Division 15 Section "Common Work Results For Plumbing".
17. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants".

B. Connections
1. Piping installation requirements are specified in other Division 14.. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect water supplies from domestic water piping to medical plumbing fixtures.
3. Connect drain piping from medical plumbing fixtures to sanitary waste and vent piping.
4. Ground equipment according to Division 16 Section "Grounding And Bonding".
5. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Verify that installed medical plumbing fixtures are categories and types specified for locations where installed.
2. Check that medical plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
3. Inspect installed medical plumbing fixtures for damage. Replace damaged fixtures and components.
4. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
5. Install fresh batteries in sensor-operated mechanisms.

D. Adjusting

1. Operate and adjust faucets and controls. Replace damaged and malfunctioning medical plumbing fixtures, fittings, and controls.
2. Adjust water pressure at faucets, shower valves, and flushometer valves to produce proper flow and stream.
3. Replace washers and seals of leaking and dripping faucets and stops.

E. Cleaning
1. Clean medical plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   a. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
   b. Remove sediment and debris from drains.
2. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

F. Protection
1. Provide protective covering for installed fixtures and fittings.
2. Do not allow use of medical plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15451a

SECTION 15451b - EMERGENCY PLUMBING FIXTURES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for emergency plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work

B. Summary
1. This Section includes the following emergency plumbing fixtures:
a. Emergency showers.
b. Eyewash equipment.
c. Self-contained eyewash equipment.
d. Personal eyewash equipment.
e. Eye/face wash equipment.
f. Hand-held drench hoses.
g. Combination units.
h. Water-tempering equipment.

C. Definitions
1. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
2. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
3. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.
4. Tepid: Moderately warm.

D. Submittals
1. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."
3. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.
4. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

1.2 PRODUCTS

A. Emergency Showers:
1. Description: Plumbed, single-shower-head horizontal, wall-mounting **OR** vertical, ceiling-mounting **OR** freestanding, **as directed,** emergency shower.
a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.

b. Supply Piping: NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32) **OR** galvanized steel **OR** chrome-plated brass or stainless steel **OR** PVC, **as directed,** with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Pull rod **OR** chain, **as directed**.
d. Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.

2. Description: Plumbed, multiple-spray emergency shower with eight **OR** 12 **OR** 16, **as directed,** small shower heads or nozzles.
   a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1-1/4 (DN 32) minimum galvanized **OR** chrome-plated brass or stainless, **as directed,** steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle **OR** Treadle, **as directed**.
3. Description: Plumbed, freeze-protected, freestanding emergency shower.
   a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1-1/4 (DN 32) galvanized steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Pull rod **OR** chain, **as directed**.
   d. Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
   e. Heating System: 120 **OR** 240, **as directed**,-V ac electric; and insulation with protective jacket.

B. Eyewash Equipment
1. Description: Plumbed, freestanding eyewash equipment.
   a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle **OR** Push bar **OR** Treadle, **as directed**.
   d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed,** bowl.
   e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2 **OR** Omit drain piping **OR** Include galvanized-steel indirect connection to drainage system, **as directed**.
2. Description: Plumbed, accessible, **as directed**, wall-mounting eyewash equipment with receptor and wall bracket.
   a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle.
   d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed,** bowl.
   e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.
3. Description: Plumbed, accessible, **as directed**, wall-mounting eyewash equipment with wall bracket.
   a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle **OR** Movement sensor, **as directed**.
4. Description: Plumbed, adjacent-to-sink, swivel, counter-mounting eyewash equipment.
   a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.

b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.

C. Self-Contained Eyewash Equipment:
1. Description: Portable, pressurized, self-contained eyewash equipment.
a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
b. Tank: 10 gal. (3.8 L), stainless steel, cylindrical, and suitable for on-floor installation.
c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
d. Piping: Chrome-plated copper alloy or stainless steel with flow regulator and stay-open control valve.
e. Control-Valve Actuator: Paddle.
f. Spray Heads: Twin with covers.
2. Description: Static, nonpressurized, self-contained eyewash equipment.
a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
b. Tank: 14 gal. (53 L) minimum, plastic, and suitable for shelf mounting.
c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
d. Actuator: Pull-down front panel.
e. Spray Heads: Protected, twin.
3. Description: Freeze-protected, static, nonpressurized, self-contained eyewash equipment with heating system.
a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
b. Tank: 14 gal. (53 L) minimum **OR** 20 gal. (76 L) minimum, **as directed**, plastic, and suitable for shelf mounting.
c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
d. Actuator: Pull-down front panel.
e. Spray Heads: Protected, twin.
f. Heating System: Electric, 120-V ac; and insulation with protective jacket.

D. Personal Eyewash Equipment:
1. Description: Portable, pressurized, personal eyewash equipment with spray heads.
a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.), **as directed**.
b. Tank: 5 gal. (19 L), stainless steel, cylindrical, and with base suitable for on-floor installation.
c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
d. Piping: Chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
e. Control-Valve Actuator: Paddle.
f. Spray Heads: Twin with covers.
2. Description: Portable, pressurized, personal eyewash equipment with spray heads and drench hose.
a. Capacity: Deliver flushing fluid at rate not less than 0.4 gpm (1.5 L/min.), **as directed**.
b. Tank: 5 gal. (19 L), stainless steel, cylindrical, and with base suitable for on-floor installation.
c. Flushing Fluid: Medically acceptable solution manufactured and labeled according to applicable regulations.
d. Piping: Chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
e. Spray-Head, Control-Valve Actuator: Paddle.

f. Spray Heads: Twin with covers.
g. Drench Hose: Rubber or plastic.
1) Control-Valve Actuator: Hand-held squeeze valve.
2) Spray Head: Single with cover.

E. Eye/Face Wash Equipment:
1. Description: Plumbed, freestanding, pedestal eye/face wash equipment.
a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle **OR** Push bar **OR** Treadle, **as directed**.
d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed,** bowl.
e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2. Include galvanized-steel indirect connection to drainage system.
2. Description: Plumbed, accessible, **as directed**, wall-mounting eye/face wash equipment with receptor and wall bracket.
a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed,** bowl.
e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.
3. Description: Plumbed, accessible, **as directed**, wall-mounting eye/face wash equipment without receptor and with wall bracket.
a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
4. Description: Plumbed, adjacent-to-sink, swivel, counter-mounting eye/face wash equipment.
a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.

F. Hand-Held Drench Hoses:
1. Description: Plumbed, wall-mounting, hand-held drench hose with wall bracket.
a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Hose: Coiled **OR** Plain, **as directed**, rubber or plastic.
e. Spray Heads: Single **OR** Twin, **as directed**.
2. Description: Plumbed, counter-mounting, hand-held drench hose.
a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Fitting: NPS 1/2 (DN 15) brass with flow regulator.
c. Hose: Rubber or plastic.
d. Control-Valve Actuator: Hand-held squeeze valve.

e. Spray Heads: Single **OR** Twin, **as directed**.

G. Combination Units:

1. Description: Plumbed, accessible, **as directed,** freestanding, with emergency shower and eyewash **OR** eye/face wash **OR** drench hose, **as directed,** equipment.
   a. Piping: Galvanized steel **OR** Chrome-plated brass or stainless steel **OR** PVC, **as directed**.
      1) Unit Supply: NPS 1-1/4 (DN 32) minimum **OR** NPS 1-1/2 (DN 40), **as directed,** from top **OR** side, **as directed**.
      2) Unit Drain: Outlet at side near bottom.
      3) Shower Supply: NPS 1 (DN 25) with flow regulator and stay-open control valve.
      4) Eyewash **OR** Eye/Face Wash **OR** Drench Hose, **as directed,** Supply: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
   b. Shower Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
      1) Control-Valve Actuator: Pull rod **OR** Pull chain **OR** Treadle, **as directed**.
      2) Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
   c. Eyewash Equipment: With capacity to deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
      1) Control-Valve Actuator: Paddle **OR** Push bar, **as directed**.
      2) Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed,** bowl.
   d. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
      1) Control-Valve Actuator: Paddle **OR** Push bar, **as directed**.
      2) Receptor: Chrome-plated brass or stainless-steel **OR** Plastic, **as directed,** bowl.
   e. Hand-Held Drench Hose: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
      1) Hose: Rubber or plastic.
      2) Control-Valve Actuator: Hand-held squeeze valve.
      3) Spray Head(s): Single **OR** Twin, **as directed**.
2. Description: Plumbed, accessible, **as directed,** freeze-protected, freestanding, with emergency shower and eye/face wash equipment.
   a. Piping: Galvanized steel.
      1) Unit Supply: NPS 1-1/4 (DN 32) minimum **OR** NPS 1-1/2 (DN 40), **as directed,** from top **OR** side **OR** bottom, **as directed**.
      2) Shower Supply: NPS 1 (DN 25) with flow regulator and stay-open control valve.
      3) Eye/Face Wash Supply: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.
   b. Heating System: Electric, 120 **OR** 240, **as directed**,-V ac; and insulation with protective jacket.
   c. Shower Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
      1) Control-Valve Actuator: Pull rod **OR** Pull chain **OR** Treadle, **as directed**.
      2) Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel **OR** plastic, **as directed**.
   d. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
      1) Control-Valve Actuator: Paddle **OR** Push bar, **as directed**.

H. Water-Tempering Equipment:

1. Description: Factory-fabricated, hot- and cold-water-tempering equipment with thermostatic mixing valve.
   a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue

cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.

2. Description: Factory-fabricated, steam and cold-water, water-tempering equipment with thermostatic mixing valve.
   a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, steam controls, heat exchanger, high-temperature-limit and freeze-protection devices, metal piping, and corrosion-resistant enclosure.
3. Description: Factory-fabricated, water-tempering equipment with electric heating.
   a. Heating System: Electric, designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, heating coils, high-temperature-limit device, metal piping, and corrosion-resistant enclosure.
      1) Electrical Characteristics: 208-V ac, 38 **OR** 220-V ac, 40 **OR** 277-V ac, 32, **as directed,** A, single phase, 60 Hz.

1.3 EXECUTION

A. Installation
1. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
2. Install fixtures level and plumb.
3. Fasten fixtures to substrate.
4. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Valves are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
   a. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency plumbing fixture.
   b. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
5. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping.
6. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Dielectric fittings are specified in Division 15 Section "Common Work Results For Plumbing".
7. Install thermometers in supply and outlet piping connections to water-tempering equipment. Thermometers are specified in Division 15 Section "Meters And Gages For Plumbing Piping".
8. Install trap and waste to wall on drain outlet of fixture receptors that are indicated to be directly connected to drainage system.
9. Install indirect waste piping to wall on drain outlet of fixture receptors that are indicated to be indirectly connected to drainage system. Drainage piping is specified in Division 15 Section "Sanitary Waste And Vent Piping".
10. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Escutcheons are specified in Division 15 Section "Common Work Results For Plumbing".
11. Fill self-contained fixtures with flushing fluid.
12. Install equipment nameplates or equipment markers on fixtures and equipment signs on water-tempering equipment. Identification materials are specified in Division 15 Section "Identification For Plumbing Piping And Equipment".
13. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
14. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment.

15. Connect hot- and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.
16. Connect cold-water and steam supply and condensate return piping to steam and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.
17. Connect cold water and electrical power to electric heating water-tempering equipment.
18. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary drainage and vent piping.
19. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary or storm drainage piping.
20. Ground equipment according to Division 16 Section "Grounding And Bonding".
21. Connect wiring according to Division 16 Section "Conductors And Cables".

B. Field Quality Control
1. Electrical-Component Testing: After electrical circuitry has been energized, test for compliance with requirements.
   a. Test and adjust controls and safeties.
2. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

C. Adjusting
1. Adjust or replace fixture flow regulators for proper flow.
2. Adjust equipment temperature settings.

END OF SECTION 15451b

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Task	Specification	Specification Description
15452	15451	Plumbing Fixtures

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SECTION 15453 - DRINKING FOUNTAINS AND WATER COOLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for drinking fountains and water coolers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Style F, freestanding drinking fountains.
b. Style W, wall-mounting drinking fountains.
c. Type PB, pressure with bubbler, Style F, freestanding water coolers.
d. Type PB, pressure with bubbler, Style W, wall-mounting water coolers.
e. Fixture supports.

C. Definitions
1. Accessible Drinking Fountain or Water Cooler: Fixture that can be approached and used by people with disabilities.
2. Cast Polymer: Dense, cast-filled-polymer plastic.
3. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.
4. Fitting: Device that controls flow of water into or out of fixture.
5. Fixture: Drinking fountain or water cooler unless one is specifically indicated.
6. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.
7. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.
3. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
4. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.
5. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.
6. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants" for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.

1.2 PRODUCTS

A. Drinking Fountains
1. Description: Accessible, Style F, freestanding drinking fountain.
   a. Pedestal:
      1) Material: Concrete **OR** Painted cast iron or steel, **as directed**.
      2) Shape: Rectangular **OR** Round, **as directed,** with offset to receptor **OR** with side receptor(s), **as directed**.
   b. Receptor(s):
      1) Number: One **OR** Two **OR** Three, **as directed**.
      2) Material: Bronze **OR** Chrome-plated brass or stainless steel, **as directed**.
      3) Shape: Rectangular **OR** Round **OR** Rounded front, **as directed**.
      4) Bubbler: One for each receptor, with adjustable stream regulator, located on deck.
   c. Controls: Foot pedal **OR** Push bar **OR** Push button, **as directed,** with adjustable stream regulator.
   d. Access to Internal Components: Panel in pedestal.
   e. Supply: NPS 3/8 (DN 10) **OR** NPS 1/2 (DN 15), **as directed**, with ball, gate, or globe valve.
   f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2 **OR** waste to drainage system, **as directed**.
2. Description: Accessible, Style F, antifreeze, freestanding drinking fountain designed to operate without draining into ground.
   a. Pedestal: Rectangular, painted cast iron or steel.
   b. Receptor: Rectangular, chrome-plated brass or stainless steel with bubbler.
   c. Control: Foot pedal with control valve assembly.
   d. Supply: NPS 1/2 (DN 15) with underground shutoff and flow-control valve assembly.
   e. Drain: Grid with NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed,** minimum waste to drainage system.
   f. Bury Depth, Grade to Valve Components: 36 inches (915 mm) **OR** 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**.
3. Description: Accessible, Style W, wall-mounting drinking fountain.
   a. Material: Bronze **OR** Metal **OR** Cast polymer **OR** Stainless steel **OR** Vitreous china complying with ASME 112.19.2M for drinking fountains with backsplash, **as directed**.
   b. Receptor Shape: Rectangular **OR** Round **OR** Rounded front, **as directed**.
   c. Back Panel: Stainless-steel wall plate behind drinking fountain.
   d. Bubblers: One **OR** Two **OR** Three, **as directed**, with adjustable stream regulator, located on deck.
   e. Control: Push button **OR** Push bar, **as directed**.
   f. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
   g. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
   h. Support: Type I, water cooler carrier. Refer to "Fixture Supports" Article.
4. Description: Accessible, Style WS, wall-mounting, semirecessed drinking fountain.
   a. Material: Stainless steel **OR** Bronze **OR** Vitreous china complying with ASME A112.19.2M for semirecessed drinking fountains, **as directed**.
   b. Receptor Shape: Concave with projecting bowl.
   c. Bubbler: One, with adjustable stream regulator, located on deck.
   d. Control: Push button **OR** Push bar, **as directed**.
   e. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
   f. Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
   g. Support: Mounting frame or brackets for attaching to substrate.
5. Description: Style RE, stainless-steel, recessed drinking fountain.
   a. Receptor Shape: Concave with flush wall flange.
   b. Bubbler: One, with adjustable stream regulator, located on deck.

c. Control: Push button **OR** bar, **as directed**.
d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
e. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
f. Support: Mounting frame or brackets for attaching to substrate.

B. Water Coolers
1. Description: ARI 1010, Type PB, pressure with bubbler, Style F, freestanding or Style FW, flush-to-wall water cooler.
a. Cabinet: All stainless steel **OR** Steel with powder-coat-finish **OR** Vinyl-covered steel with stainless-steel top, **as directed**.
b. Bubbler: One, with adjustable stream regulator, located on deck.
c. Control: Push button **OR** Foot pedal, **as directed**.
d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
1) Capacity: 5 gph (0.0053 L/s) **OR** 8 gph (0.0084 L/s) **OR** 10 gph (0.0105 L/s) **OR** 14 gph (0.0147 L/s), **as directed,** of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
2) Electrical Characteristics: 1/6 **OR** 1/5 **OR** 1/4, **as directed**, hp; 120-V ac; single phase; 60 Hz.
2. Description: ARI 1010, Type PBC, pressure with bubbler and compartment, Style F, freestanding water cooler.
a. Cabinet: All stainless steel **OR** Vinyl-covered steel with stainless-steel top, **as directed,** with refrigerated compartment in front panel.
b. Bubbler: One, with adjustable stream regulator, located on deck.
c. Control: Push button.
d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
g. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
1) Capacity: 3 gph (0.0032 L/s) of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
2) Electrical Characteristics: 1/8 hp; 120-V ac; single phase; 60 Hz.
3. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler for adult **OR** child, **as directed,**-mounting height.
a. Cabinet: Single **OR** Bilevel with two attached cabinets **OR** Bilevel with two attached cabinets and with bilevel skirt kit, **as directed**, all stainless steel **OR** vinyl-covered steel with stainless-steel top, **as directed**.
b. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
c. Control: Push button **OR** Push bar, **as directed**.
d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
f. Drain(s): Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.1.

g. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
   1) Capacity: 5 gph (0.0053 L/s)\ **OR** 8 gph (0.0084 L/s), **as directed**, of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
   2) Electrical Characteristics: 1/6 **OR** 1/5 **OR** 1/4 **OR** 1/3, **as directed,** hp; 120-V ac; single phase; 60 Hz.

h. Support: Type I **OR** II, **as directed**, water cooler carrier. Refer to "Fixture Supports" Article.

4. Description: Accessible, ARI 1010, Type PB, pressure with bubbler, Style WS, semirecessed water cooler.
   a. Cabinet: All stainless steel **OR** Vinyl-covered steel with stainless-steel top, **as directed**.
   b. Bubbler: One, with adjustable stream regulator, located on deck.
   c. Control: Push button **OR** Push bar, **as directed**.
   d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
   e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
   f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
   g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
      1) Capacity: 8 gph (0.0084 L/s) **OR** 12 gph (0.0126 L/s), **as directed,** of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
      2) Electrical Characteristics: 1/6 **OR** 1/5, **as directed,** hp; 120-V ac; single phase; 60 Hz.
   h. Support: Mounting frame or brackets for attaching to substrate.

5. Description: ARI 1010, Type PB, pressure with bubbler, Style RE, recessed water cooler.
   a. Cabinet: All stainless steel.
   b. Bubbler: One, with adjustable stream regulator, located on deck.
   c. Control: Push button **OR** bar, **as directed**.
   d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
   e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
   f. Drain: Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.
   g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
      1) Capacity: 8 gph (0.0084 L/s) **OR** 12 gph (0.0126 L/s), **as directed,** of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
      2) Electrical Characteristics: 1/6 **OR** 1/5, **as directed,** hp; 120-V ac; single phase; 60 Hz.
   h. Ventilation Grille: Stainless steel, located above **OR** below, **as directed,** fountain.
   i. Support: Mounting frame for attaching to substrate.

C. Water Station Water Coolers
   1. Description: Water-station configuration, freestanding, cabinet water cooler with top-mounting glass fillers.
      a. Cabinet: All stainless steel **OR** Enameled-steel panels with stainless-steel top, **as directed**, 0.05 inch (1.3 mm) thick; and 32 inches (813 mm) **OR** 36 inches (915 mm), **as directed**, high.

b. Receptors: Two **OR** Four, **as directed,** stainless-steel bowls, with grid drain and bottom outlet in top; with two facing front and two facing back.
c. Glass Fillers: Two **OR** Four, **as directed**, push-back type **OR** pedestal type, **as directed**, on top, over receptors.
d. Tray Slides: One on front and one on back, stainless steel.
e. Supply: NPS 1/2 (DN 15) with ball, gate, or globe valve, and connected to filter, chiller, and each glass filler.
f. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
g. Drain: Waste piping from each receptor connected to NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, trap and waste to wall **OR** indirect waste to floor receptor, **as directed,** complying with ASME A112.18.2.
h. Cooling System: Electric, complying with ARI 1010, for Type R remote water coolers.
1) Chassis: Galvanized or corrosion-resistant-coated steel.
2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
3) Storage Tank: 2 gal. (7.6 L) **OR** 4 gal. (15.1 L) **OR** 6 gal. (22.7 L) **OR** 14 gal. (53 L) **OR** 25 gal. (95 L), **as directed**, stainless steel.
4) Controls: Adjustable thermostat.
5) One-Hour Peak Capacity Rate: 8 gph (0.0084 L/s) **OR** 12 gph (0.0126 L/s) **OR** 18 gph (0.0189 L/s) **OR** 29 gph (0.0305 L/s) **OR** 50 gph (0.0526 L/s), **as directed,** of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
6) Electrical Characteristics: 1/5 **OR** 1/4 **OR** 1/3 **OR** 1/2 **OR** 3/4, **as directed,** hp; 120 **OR** 240 **OR** 277 **OR** 480, **as directed,**-V ac; single phase; 60 Hz.

2. Description: Water-station configuration, freestanding, cabinet water cooler with front-mounting glass fillers.
a. Cabinet: All stainless steel **OR** Enameled-steel panels with stainless-steel top, **as directed**, 0.05 inch (1.3 mm) thick; and 42 inches (1067 mm) **OR** 48 inches (1219 mm), **as directed**, high.
b. Receptors: One **OR** Two, **as directed,** stainless-steel tray(s), with antisplash design, drain, and bottom outlet, in vertical panel(s), with one facing front and one facing back.
c. Glass Fillers: Two **OR** Four, **as directed**, push-back type, on vertical panel(s), over receptor(s).
d. Shelves: One **OR** Two, **as directed**, stainless steel, on each side panel.
e. Supply: NPS 1/2 (DN 15) with ball, gate, or globe valve, and connected to filter, chiller, and each glass filler.
f. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
g. Drain: NPS 1-1/4 (DN 32) **OR** NPS 1-1/2 (DN 40), **as directed**, trap and waste to wall **OR** indirect waste to floor receptor, **as directed,** complying with ASME A112.18.2.
h. Cooling System: Electric, complying with ARI 1010, for Type R remote water coolers.
1) Chassis: Galvanized or corrosion-resistant-coated steel.
2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
3) Storage Tank: 6 gal. (22.7 L) **OR** 14 gal. (53 L) **OR** 25 gal. (95 L) **OR** 30 gal. (113.6 L) **OR** 40 gal. (151.4 L), **as directed**, stainless steel.
4) Controls: Adjustable thermostat.
5) One-Hour Peak Capacity Rate: 18 gph (0.0189 L/s) **OR** 29 gph (0.0305 L/s) **OR** 50 gph (0.0526 L/s) **OR** 65 gph (0.0684 L/s) **OR** 85 gph (0.0894 L/s), **as directed,** of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
6) Electrical Characteristics: 1/3 **OR** 1/2 **OR** 3/4 **OR** 1 **OR** 1-1/2, **as directed**, hp; 120 **OR** 240 **OR** 277 **OR** 480, **as directed,**-V ac; single phase; 60 Hz.

D. Remote Water Coolers

1. Description: ARI 1010, Style R, remote chiller equipment for installation separate from drinking fountains. Include filter, reverse-osmosis system and ultra-violet-disinfection equipment, **as directed**.
   a. Cooling System: Electric.
      1) Chassis: Galvanized or corrosion-resistant-coated steel.
      2) Chiller: Hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, and refrigerant.
      3) Storage Tank: 0.5 gal. (1.9 L) **OR** 4 gal. (15.1 L), **as directed**, stainless steel.
      4) Controls: Adjustable thermostat.
      5) Capacity: 5 gph (0.0053 L/s) **OR** 8 gph (0.0084 L/s) **OR** 14 gph (0.0147 L/s), **as directed,** of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.
      6) Electrical Characteristics: 1/5 **OR** 1/4 **OR** 1/3, **as directed,** hp; 120 **OR** 240 **OR** 277 **OR** 480, **as directed,**-V ac; single phase; 60 Hz.
   b. Ventilation Grille: Stainless steel.
   c. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.

E. Fixture Supports
1. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
   a. Type I: Hanger-type carrier with two vertical uprights.
   b. Type II: Bilevel, hanger-type carrier with three vertical uprights.
   c. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

1.3 EXECUTION

A. Applications
1. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
2. Use mounting frames for recessed water coolers, unless otherwise indicated.
3. Set freestanding and pedestal drinking fountains on floor.
4. Set remote water coolers on floor, unless otherwise indicated.
5. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

B. Installation
1. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.
2. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.
3. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.
4. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
5. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
6. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 15 Section "Common Work Results For Plumbing".

7. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants".

C. Connections
1. Connect fixtures with water supplies, traps, and risers, and with soil, waste, and vent piping. Use size fittings required to match fixtures.
2. Ground equipment according to Division 16 Section "Grounding And Bonding".
3. Connect wiring according to Division 16 Section "Conductors And Cables".

D. Field Quality Control
1. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
   a. Remove and replace malfunctioning units and retest as specified above.
   b. Report test results in writing.

E. Adjusting
1. Adjust fixture flow regulators for proper flow and stream height.
2. Adjust water cooler temperature settings.

END OF SECTION 15453

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Task	Specification	Specification Description
15454	01352	No Specification Required
15454	15453	Drinking Fountains And Water Coolers
15457	15451	Plumbing Fixtures
15458	15451	Plumbing Fixtures

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SECTION 15459 - SECURITY PLUMBING FIXTURES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for security plumbing fixtures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following security plumbing fixtures and related components:
   a. Combination units.
   b. Drinking fountains.
   c. Lavatories.
   d. Service sinks.
   e. Shampoo bowls.
   f. Showers.
   g. Urinals.
   h. Water closets.
   i. Flushometer valves for vitreous-china water closets.
   j. Fixture supports for front-mounting, stainless-steel fixtures and vitreous-china, wall-mounting fixtures.

C. Definitions
1. Accessible Fixture: Security plumbing fixture that can be approached and used by people with disabilities.
2. Back-Mounting-Type Fixture: Security plumbing fixture designed to mount on wall sleeve built into wall so installation and removal of fixture and piping and other components are only accessible from service space behind wall.
3. Front-Mounting-Type Fixture: Security plumbing fixture designed to mount on fixture support with installation and removal from fixture side of wall, and piping and other components are accessible from access panels in fixture or wall.

D. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
   a. Product Data for Credit WE 2, 3.1, and 3.2: Documentation indicating flow and water consumption requirements.
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Field quality-control test reports.
5. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act", **as directed**; about security plumbing fixtures for people with disabilities. Comply with requirements in "Energy Policy Act" about water flow and consumption rates for plumbing fixtures.
3. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

4. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

1.2 PRODUCTS

A. Combination Units
1. Security Combination Units:
a. Description: Back-mounting, cabinet, security plumbing fixture with integral water closet and lavatory; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
1) Water Closet: Comply with IAPMO PS 61 for water-closet component.
a) Bowl: Elongated, with back inlet, integral trap, blowout design with back **OR** siphon-jet design with back **OR** siphon-jet design with floor, **as directed**, outlet and contoured seat.
i. Seat Surface: SSINA No. 7 polished finish.
ii. Punching: Provide two holes for installation of separate toilet seat.
iii. Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint **OR** vertical, **as directed**.
b) Toilet Seat: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
c) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
2) Lavatory: In top of cabinet.
a) Receptor: Oval **OR** Rectangular, **as directed**, bowl with integral soap depression.
b) Hot- and Cold-Water and Bubbler, **as directed**, Supply Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with push-button actuation and individual check stop.
c) Filler Spout: Backsplash **OR** Deck, **as directed**, mounted.
d) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2 **OR** concealed waste piping to spill into water-closet bowl, **as directed**.
e) Toothbrush Holders: One on each **OR** left **OR** right, **as directed**, side of backsplash.
f) Towel Hooks: One **OR** Two, **as directed**, on each **OR** left **OR** right, **as directed**, side of fixture.
g) Bubbler Location: On backsplash **OR** deck, **as directed**.
3) Cabinet Configuration: Rectangular apron **OR** Five-sided apron with two angled sides **OR** Four-sided apron with angled left side **OR** Four-sided apron with angled right side, **as directed**, made for above-floor **OR** on-floor, **as directed**, installation and with backsplash.
a) Water-Closet Bowl Location: Centered on front **OR** Left of center on front **OR** Right of center on front **OR** On angled left side **OR** On angled right side, **as directed**, of apron.
b) Toilet Paper Holder: Recessed, 0.063-inch (1.6-mm) minimum thickness, stainless steel complying with ASTM A 666, Type 304 and located above water closet and centered in front **OR** in front **OR** right of center in front **OR** left of center in front **OR** in angled right side **OR** in angled left side **OR** in right side **OR** in left side, **as directed**, of apron.

4) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support entire fixture. Include steel bars or other design that will prevent escape if fixture is removed.

B. Drinking Fountains

1. Security Drinking Fountains, Back-Mounting:

a. Description: Back-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

1) Receptor: Bowl or depression in top and with backsplash.

2) Bubbler Location: On backsplash **OR** deck, **as directed**.

3) Bubbler Water-Supply Valve: Pneumatic type with push-button actuation.

4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.

5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

2. Security Drinking Fountains, Front-Mounting:

a. Description: Front-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

1) Receptor: Bowl or depression in top and with backsplash.

2) Bubbler Location: On backsplash **OR** deck, **as directed**.

3) Bubbler Water-Supply Valve: Pneumatic type with push-button actuation.

4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum tailpiece, trap, and waste, and complying with ASME A112.18.2.

5) Access to Internal Components: Vandal-resistant access panels.

6) Mounting Device: Wall bracket.

7) Support: Chair carrier. Refer to "Fixture Supports" Article.

C. Lavatories

1. Security Lavatories, Back-Mounting:

a. Description: Back-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

1) Receptor: Oval **OR** Rectangular, **as directed**, bowl with integral soap depression and backsplash.

2) Hot- and Cold-Water and Bubbler, **as directed**, Supply Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with push-button actuation and individual check stop.

3) Filler Spout: Backsplash **OR** Deck, **as directed**, mounted.

4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2.

5) Toothbrush Holders: One on each **OR** left **OR** right, **as directed**, side of backsplash.

6) Towel Hooks: One **OR** Two, **as directed**, on each **OR** left **OR** right, **as directed**, side of fixture.

7) Bubbler Location: On backsplash **OR** deck, **as directed**.

8) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

2. Security Lavatories, Front-Mounting:

a. Description: Front-mounting, accessible, **as directed**, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness,

ASTM A 666, Type 304, stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

1) Receptor: Oval **OR** Rectangular, **as directed**, bowl with integral soap depression and backsplash.
2) Hot- and Cold-Water and Bubbler, **as directed**, Supply Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with push-button actuation and individual check stop.
3) Filler Spout: Backsplash **OR** Deck, **as directed**, mounted.
4) Drain: Integral punched grid with NPS 1-1/4 (DN 32) minimum tailpiece, trap, and waste complying with ASME A112.18.2.
5) Toothbrush Holders: One on each **OR** left **OR** right, **as directed**, side of backsplash.
6) Towel Hooks: One **OR** Two, **as directed**, on each **OR** left **OR** right, **as directed**, side of fixture.
7) Bubbler Location: On backsplash **OR** deck, **as directed**.
8) Access to Internal Components: Vandal-resistant access panels.
9) Mounting Device: Wall bracket.
10) Support: Chair carrier. Refer to "Fixture Supports" Article.

3. Security Lavatories, Vitreous-China:
   a. Description: ASME A112.19.2M, vitreous-china security plumbing fixture made for institutional applications, with integral soap depression and NPS 1-1/4 (DN 32) waste outlet and with factory-installed, push-button, self-closing, chrome-plated brass faucets complying with ASME A112.18.1.
      1) Waste: NPS 1-1/4 (DN 32) minimum piping and trap complying with ASME A112.18.2.
      2) Mounting Device: Wall bracket.
      3) Support: Chair carrier. Refer to "Fixture Supports" Article.

D. Service Sinks
1. Security Service Sinks:
   a. Description: Back-mounting security plumbing fixture made for above-floor **OR** on-floor, **as directed**, installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Receptor: Rectangular bowl with high backsplash.
      2) Hot- and Cold-Water-Supply Valves: Pneumatic type with push-button actuation and individual check stop.
      3) Filler Spout: Backsplash mounted.
      4) Drain: Grid with NPS 2 (DN 50) waste and trap complying with ASME A112.18.2.
      5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

E. Shampoo Bowls
1. Security Shampoo Bowls:
   a. Description: Front-mounting security plumbing fixture made for above-floor **OR** counter-mounting, **as directed**, installation; fabricated from 0.078-inch (2.0-mm) thickness, ASTM A 666, Type 304 stainless steel and corrosion-resistant metal internal piping and bracing.
      1) Receptor: Bowl with contoured neck rest.
      2) Finish: White **OR** Black, **as directed**, enamel.
      3) Exposed Surfaces without Enamel Finish: SSINA No. 4 polished finish.
      4) Faucet: Dial single-lever control with vacuum breaker, hose, and spray.
      5) Drain: Basket strainer with NPS 1-1/2 (DN 40) tailpiece, trap, and waste to wall complying with ASME A112.18.2.

6) Access to Internal Components: Vandal-resistant access panels.
7) Mounting Device: Wall bracket.
8) Support: Chair carrier. Refer to "Fixture Supports" Article.

F. Showers

1. Security Showers, Back-Mounting, Recessed:
   a. Description: Back-mounting, accessible, **as directed**, recessed security plumbing fixture made with wall plate for flush installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Wall type with shower head and soap dish.
      2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stop.
      3) Shower: Hose with vandal-resistant, hand-held **OR** Vandal-resistant, fixed-type **OR** Vandal-resistant, swivel-type, **as directed**, head.
      4) Soap Dish: Recessed, stainless steel.
      5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.
2. Security Showers, Front-Mounting, Recessed:
   a. Description: Front-mounting, accessible, **as directed**, recessed security plumbing fixture made with wall plate for flush installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Wall type with shower head and soap dish.
      2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stop.
      3) Shower: Hose with vandal-resistant, hand-held **OR** Vandal-resistant, fixed-type **OR** Vandal-resistant, swivel-type, **as directed**, head.
      4) Soap Dish: Recessed, stainless steel.
      5) Access to Internal Components: Vandal-resistant access panels.
      6) Mounting Device: Wall-mounting frame.
3. Security Showers, Front-Mounting, Surface Installation:
   a. Description: Front-mounting, accessible, **as directed**, security plumbing fixture made for surface installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Wall type with shower head and soap dish.
      2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stops.
      3) Soap Dish: Recessed, stainless steel.
      4) Access to Internal Components: Vandal-resistant access panels.
      5) Mounting Device: Wall-mounting frame.
4. Security Showers, Back-Mounting, Accessible:
   a. Description: Back-mounting, accessible, cabinet, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Cabinet 42 or 44 by 36 inches (1065 or 1120 by 915 mm) **OR** 48 by 36 inches (1220 by 915 mm), **as directed**, with floor and top, **as directed**, with stainless-steel soap dish, towel hook, drain, seat, and grab bar.

2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stops.
3) Shower: Hose with vandal-resistant, hand-held head.
4) Drain: NPS 2 (DN 50) strainer, waste to wall, and trap complying with ASME A112.18.2.
5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

5. Security Showers, Back-Mounting:
   a. Description: Back-mounting, cabinet, security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Cabinet 30 by 30 inches (760 by 760 mm) **OR** 32 by 32 inches (815 by 815 mm) **OR** 36 by 36 inches (915 by 915 mm), **as directed**, with floor and top, **as directed**, and with stainless-steel soap dish, towel hook, and drain.
      2) Tempered-Water-Supply **OR** Hot- and Cold-Water-Supply, **as directed**, Valves: Pneumatic **OR** Mechanical-metering **OR** Electric-solenoid, **as directed**, type with individual check stops.
      3) Shower: Vandal-resistant, fixed **OR** Fixed **OR** Swivel, **as directed**,-type head.
      4) Drain: NPS 2 (DN 50) strainer, waste to wall, and trap complying with ASME A112.18.2.
      5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.

G. Urinals
1. Security Urinals, Back-Mounting:
   a. Description: Back-mounting security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Type and Configuration: Blowout **OR** Washout, **as directed**, type with back inlet and extended shields.
         OR
         Type and Configuration: Washout, trough type, and 36 inches (915 mm) **OR** 48 inches (1220 mm), **as directed**, wide.
      2) Drain: Strainer with NPS 2 (DN 50) tailpiece, trap under fixture, and drain piping.
      3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
      4) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture.
2. Security Urinals, Front-Mounting:
   a. Description: Front-mounting security plumbing fixture; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Type and Configuration: Blowout **OR** Washout, **as directed**, type with back **OR** top, **as directed**, inlet and extended shields.
         OR
         Type and Configuration: Washout, trough type, and 36 inches (915 mm) **OR** 48 inches (1220 mm), **as directed**, wide.
      2) Drain: Strainer with NPS 2 (DN 50) tailpiece, trap under fixture, and drain piping complying with ASME A112.18.2.

3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed** consumption. Refer to "Flushometer Valves" Article.
4) Support: Chair carrier. Refer to "Fixture Supports" Article.

3. Security Urinals, Back-Mounting, Wall-And-Floor Installation:
   a. Description: Back-mounting security plumbing fixture made for wall-and-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Type and Configuration: Washout, stall type with back inlet.
      2) Drain: Strainer with NPS 2 (DN 50) outlet.
      3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
4. Security Urinals, Front-Mounting, Wall-And-Floor Installation:
   a. Description: Front-mounting security plumbing fixture made for wall-and-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Type and Configuration: Washout, stall type with back **OR** top, **as directed**, inlet.
      2) Drain: Strainer with NPS 2 (DN 50) outlet.
      3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 1.5-gal./flush (5.7-L/flush) **OR** 1.0-gal./flush (3.78-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
      4) Support: Chair carrier. Refer to "Fixture Supports" Article.

H. Water Closets
1. Security Water Closets, Back-Mounting, Above Floor Installation:
   a. Description: IAPMO PS 61, back-mounting, accessible, **as directed**, security plumbing fixture made for above-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Compact design, with bowl on wall flange.
      2) Bowl: Elongated, with back inlet, integral trap, blowout design with back outlet and contoured seat.
         a) Seat Surface: SSINA No. 7 polished finish.
         b) Punching: Provide two holes for installation of separate toilet seat.
         c) Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint.
      3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
      4) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed,** commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
      5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture. Include steel bars or other design that will prevent escape if fixture is removed.
2. Security Water Closets, Back-Mounting, Off Floor Installation:
   a. Description: IAPMO PS 61, back-mounting, accessible, **as directed**, security plumbing fixture made for off-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR**

0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

1) Configuration: Standard design.
2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, blowout **OR** siphon-jet, **as directed**, design with back outlet and contoured seat.
   a) Seat Surface: SSINA No. 7 polished finish.
   b) Punching: Provide two holes for installation of separate toilet seat.
   c) Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint.
3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
4) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed,** commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
5) Wall Sleeve: Galvanized-steel frame of dimensions required to match and support fixture. Include steel bars or other design that will prevent escape if fixture is removed.

3. Security Water Closets, Front-Mounting, Off-Floor Installation:
   a. Description: IAPMO PS 61, front-mounting, accessible, **as directed**, security plumbing fixture made for off-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Standard design.
      2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, blowout **OR** siphon-jet, **as directed**, design with back outlet and contoured seat.
         a) Seat Surface: SSINA No. 7 polished finish.
         b) Punching: Provide two holes for installation of separate toilet seat.
      3) Access to Internal Components: Vandal-resistant access panels.
      4) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
      5) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
      6) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
4. Security Water Closets, Back-Mounting, On-Floor Installation:
   a. Description: IAPMO PS 61, back-mounting security plumbing fixture made for on-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4, polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Standard design.
      2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, blowout **OR** siphon-jet, **as directed**, design with back outlet and contoured seat.
         a) Seat Surface: SSINA No. 7 polished finish.
         b) Punching: Provide two holes for installation of separate toilet seat.
         c) Drain: NPS 4 (DN 100) **OR** NPS 3 (DN 80), **as directed**, horizontal with cleanout and slip joint.

3) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
4) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.

5. Security Water Closets, Front-Mounting, On-Floor Installation:
   a. Description: IAPMO PS 61, front-mounting security plumbing fixture made for on-floor installation; fabricated from 0.078-inch (2.0-mm) minimum **OR** 0.109-inch (2.8-mm), **as directed**, thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.
      1) Configuration: Standard design.
      2) Bowl: Elongated, with back **OR** top, **as directed**, inlet, integral trap, siphon-jet design with back **OR** floor, **as directed**, outlet and contoured seat.
         a) Seat Surface: SSINA No. 7 polished finish.
         b) Punching: Provide two holes for installation of separate toilet seat.
      3) Access to Internal Components: Vandal-resistant access panels.
      4) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button **OR** Exposed flushometer valve with oscillating lever-handle, **as directed**, mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
      5) Toilet Seat, **as directed**: ANSI Z124.5, white, **OR** black, **as directed**, commercial, heavy-duty, elongated, open front with cover, **as directed**, with check **OR** self-sustaining **OR** self-sustaining, check, **as directed**, hinges.
      6) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
6. Security Water Closets, Vitreous-China, Wall-Mounting, On-Floor Installation
   a. Description: ASME A112.19.2M, vitreous-china, wall-mounting and on-floor installation, back-inlet, blowout **OR** siphon-jet, **as directed**, fixture with integral contoured seat and made for institutional applications.
      1) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) **OR** 1.6-gal./flush (6.0-L/flush), **as directed**, consumption. Refer to "Flushometer Valves" Article.
      2) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.
7. Security Water Closets, Vitreous-China, Wall-Mounting:
   a. Description: ASME A112.19.2M, vitreous-china, accessible, **as directed**, wall-mounting, back-inlet, blowout fixture with integral contoured seat and made for institutional applications.
      1) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and 3.5-gal./flush (13.3-L/flush) consumption. Refer to "Flushometer Valves" Article.
      2) Support: Combination support and waste fitting assembly. Refer to "Fixture Supports" Article.

I. Flushometer Valves
   1. Flushing Devices for Vitreous-China Water Closets:
      a. Description: Flushometer valves, trim, and components complying with ASSE 1037. Include brass body, check-stop inlet, diaphragm operation, vacuum breaker, tailpiece, chrome-plated finish on exposed components, and non-hold-open feature on oscillating lever-handle trip mechanism. See fixture type for consumption.

J. Fixture Supports
   1. Back-mounting fixtures are installed on wall sleeves. Front-mounting and wall-mounting fixtures are installed on supports specified herein.

2. Off-Floor, Plumbing Fixture Supports:
   a. Description: ASME A112.6.1M carriers with dimensions and trim matching fixture.
      1) Stainless-Steel, Front-Mounting Fixtures: With modifications.
         a) Drinking Fountains: Type I drinking fountain carrier.
         b) Lavatories: Type III lavatory carrier.
         c) Shampoo Bowls: Type II sink carrier.
         d) Urinals: Type I urinal carrier with inlet seal unless Type II is required.
         e) Water Closets: Combination support and waste fitting assembly.
      2) Vitreous-China, Wall-Mounting Fixtures:
         a) Lavatories: Type III lavatory carrier.
         b) Water Closets: Combination support and waste fitting assembly.
      3) Carriers: With vertical steel uprights with feet. Include tie rods, bearing plates, and mounting studs matching fixture to be supported.
      4) Combination Support and Waste Fitting Assemblies: With feet and inlet seal.
      5) Carriers for Accessible Fixtures: Include rectangular, vertical steel uprights instead of steel pipe uprights.

1.3 EXECUTION

A. Security Plumbing Fixture Installation
   1. Install back-mounting-type, stainless-steel security plumbing fixtures as follows:
      a. Install wall sleeve in wall.
      b. Install fixture on wall sleeve; mount components on or attached to wall sleeve with access from accessible service space.
      c. Extend supply piping from service space to fixture.
      d. Install soil and waste piping from fixture and extend into service space.
      e. Install fixture trap in service space instead of below fixture drain.
   2. Install front-mounting-type, stainless-steel security plumbing fixtures as follows:
      a. Install fixture support or mounting bracket.
      b. Install fixture on support; mount components inside of or attached to fixture.
      c. Extend supply piping from pipe space to fixture.
      d. Install trap below fixture and extend soil and waste piping into pipe space.
   3. Install vitreous-china security plumbing fixtures onto accessible service space as follows:
      a. Install fixture support in service space.
         1) Use combination support and waste fitting assembly for water closet.
         2) Use chair carriers for lavatory.
      b. Install fixture on support.
      c. Install components in service space.
   4. Install vitreous-china security plumbing fixtures onto accessible pipe space as follows:
      a. Install fixture support in pipe space.
         1) Use combination support and waste fitting assembly for water closet.
         2) Use carrier support for lavatory.
      b. Install fixture on support.
      c. Install components in pipe space with access panels. See Division 08 Section "Access Doors And Frames" for access panels not in this Section.
   5. Install security plumbing fixture outlets with gasket seals.
   6. Install fixtures designated "accessible" according to ICC A117.1 for heights, dimensions, and clearances.
   7. Install fixtures level and plumb.
   8. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 15 Section "General-duty Valves For Plumbing Piping".

9. Install dielectric fittings in water-supply piping to fixtures if piping and fixture connections are made of different metals. See Division 15 Section "Common Work Results For Plumbing" for dielectric fittings.
10. Install toilet seats on water closets and combination units if seats are indicated.

B. Connections
1. Piping installation requirements are specified in other Division 14. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect hot- and cold-water supply piping to security plumbing fixtures. Include supply stops, if specified, or ball valve on each supply. Ball valves are specified in Division 15 Section "General-duty Valves For Plumbing Piping".
3. Connect soil and waste piping to security plumbing fixtures.
4. Ground equipment according to Division 16 Section "Grounding And Bonding".
5. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Testing: After installing security plumbing fixtures and after electrical circuitry has been energized, test for compliance with requirements.
   b. Remove and replace malfunctioning security plumbing fixtures. Retest as specified above after repairs or replacements are made.

D. Adjusting
1. Operate and adjust water-supply flushometers and flow-control valves on security plumbing fixtures.

E. Cleaning
1. Clean security plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
   a. Remove faucet spouts and strainers, remove sediment and debris, and reinstall spouts and strainers.
   b. Remove sediment and debris from drains.
2. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

F. Protection
1. Provide protective covering for installed security plumbing fixtures and fittings.
2. Do not allow use of security plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15459

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Task	Specification	Specification Description
15607	01352	No Specification Required

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SECTION 15624 - CONDENSING BOILERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for condensing boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, pulse-combustion, fire-tube, water-tube, and water-jacketed condensing boilers, trim, and accessories for generating hot water or steam.

C. Submittals
1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
   a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
      1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
      2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
   b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.
8. Other Informational Submittals:
   a. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
5. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
a. Warranty Period for Pulse-Combustion Boilers:
1) Heat Exchanger Damaged by Thermal Shock: 10 years from date of Substantial Completion.
2) Heat-Exchanger Corrosion: Prorated **OR** Nonprorated, **as directed**, for five years from date of Substantial Completion.
b. Warranty Period for Fire-Tube Condensing Boilers:
1) Leakage and Materials: 10 years from date of Substantial Completion.
2) Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated **OR** Nonprorated for five years from date of Substantial Completion.
c. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Substantial Completion.
d. Warranty Period for Water-Jacketed Condensing Boilers:
1) Leakage and Materials: Eight years from date of Substantial Completion.
2) Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated **OR** Nonprorated, **as directed**, for five years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Units: Pulse-Combustion Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, pulse-combustion condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
2. Heat Exchanger: Type 316L, stainless-steel **OR** Carbon-steel, **as directed**, primary and secondary combustion chamber.
3. Pressure Vessel: Carbon steel with welded heads and tube connections.
4. Exhaust Decoupler: Fiberglass composite material in a corrosion-resistant steel box.
5. Burner: Natural **OR** Propane, **as directed**, gas, self-aspirating and self-venting after initial start.
6. Blower: Centrifugal fan to operate only during start of each burner sequence.
a. Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
7. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
8. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
9. Casing:
a. Jacket: Sheet metal, with snap-in or interlocking closures.
b. Control Compartment Enclosure: NEMA 250, Type 1A.
c. Finish: Baked-enamel **OR** Powder-coated, **as directed**, protective finish.
d. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
e. Draft Hood: Integral **OR** External, **as directed**.
f. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
g. Mounting base to secure boiler to concrete base.
1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

10. Mufflers: Carbon-steel intake muffler and stainless-steel exhaust.
11. Condensate Trap: Cast-iron body with stainless-steel internal parts.

B. Manufactured Units: Fire-Tube Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
2. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.
3. Pressure Vessel: Carbon steel with welded heads and tube connections.
4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft.
5. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
   a. Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
      1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
6. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
7. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
8. Casing:
   a. Jacket: Sheet metal **OR** Plastic, **as directed**, with snap-in or interlocking closures.
   b. Control Compartment Enclosures: NEMA 250, Type 1A.
   c. Finish: Baked-enamel **OR** Powder-coated, **as directed**, protective finish for sheet metal jacket.
   d. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber **OR** polyurethane-foam, **as directed**, insulation surrounding the heat exchanger.
   e. Combustion-Air Connections: Inlet and vent duct collars.
   f. Mounting base to secure boiler.
      1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

C. Manufactured Units: Water-Tube Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
2. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.
3. Combustion Chamber: Stainless steel, sealed.
4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft drawing from gas premixing valve.
5. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
   a. Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
      1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
6. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
7. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.
8. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.
9. Casing:
   a. Jacket: Sheet metal, with snap-in or interlocking closures.
   b. Control Compartment Enclosures: NEMA 250, Type 1A.

c. Finish: Textured epoxy.
d. Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
e. Combustion-Air Connections: Inlet and vent duct collars.
f. Mounting base to secure boiler.
1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

D. Manufactured Units: Water-Jacketed Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water heating service only.
2. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.
3. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.
4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft; swing-open front and burner observation port.
5. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.
a. Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
6. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.
7. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
8. Casing:
a. Jacket: Sheet metal, with snap-in or interlocking closures.
b. Control Compartment Enclosures: NEMA 250, Type 1A.
c. Finish: Powder-coated protective finish.
d. Insulation: Minimum 4-inch- (100-mm-) thick, mineral-fiber insulation surrounding the heat exchanger.
e. Combustion-Air Connections: Inlet and vent duct collars.
f. Mounting base to secure boiler.
1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

E. Trim: For Hot-Water Boilers.
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
3. Safety Relief Valve: ASME rated.
4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.

7. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

F. Trim: For Steam Boilers.
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
3. Safety Relief Valve:
   a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
   b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
      1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
5. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
6. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.
7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.

G. Controls
1. Refer to Division 15 Section "Hvac Instrumentation And Controls".
   OR
   Boiler operating controls shall include the following devices and features:
   a. Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
   b. Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.
   c. Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
      OR
      Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
   d. Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
      1) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
   a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler or pressure for steam boiler.

b. Low-Water Cutoff Switch: Electronic for hot-water boilers or Float and electronic for steam boilers probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**,-reset type.
c. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

3. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
   a. Hardwired Points:
      1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
      2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
   b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

H. Electrical Power
1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 15.
   OR
   Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
   a. House in NEMA 250, Type 1 enclosure.
   b. Wiring shall be numbered and color-coded to match wiring diagram.
   c. Install factory wiring outside of an enclosure in a metal raceway.
   d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
   e. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
   f. Provide each motor with overcurrent protection.

I. Venting Kits
1. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
2. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

J. Source Quality Control
1. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
2. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
3. Allow Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

1.3 EXECUTION

A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 02..
2. Vibration Isolation for Equipment Supported on Slabs-On -Grade: Elastomeric isolation pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
4. Assemble and install boiler trim.
5. Install electrical devices furnished with boiler but not specified to be factory mounted.
6. Install control wiring to field-mounted electrical devices.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
4. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 15 Section "Common Work Results For Hvac".
5. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
6. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
7. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
8. Install piping from safety relief valves to nearest floor drain.
9. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
10. Boiler Venting:
    a. Install flue venting kit and combustion-air intake.
    b. Connect full size to boiler connections. Comply with requirements in Division 15 Section "Breechings, Chimneys, And Stacks".
11. Ground equipment according to Division 16 Section "Grounding And Bonding".
12. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
    a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
    a. Perform installation and startup checks according to manufacturer's written instructions.
    b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
    c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
    d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
        1) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature **OR** steam pressure, **as directed**.
        2) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Remove and replace malfunctioning units and retest as specified above.
4. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
5. Performance Tests, **as directed**:

a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
c. Perform field performance tests to determine capacity and efficiency of boilers.
   1) Test for full capacity.
   2) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
d. Repeat tests until results comply with requirements indicated.
e. Provide analysis equipment required to determine performance.
f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
g. Notify the Owner in advance of test dates.
h. Document test results in a report and submit to the Owner.

D. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 15624

SECTION 15624a - WATER-TUBE BOILERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for water-tube boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, finned water-tube boilers, trim, and accessories for generating hot water.
2. This Section includes packaged, water-tube boilers, trim, and accessories for generating hot water or steam with the following configurations, burners, and outputs:
   a. Factory and Field assembled.
   b. Atmospheric gas, Forced-draft gas, Oil, and Combination gas and oil burner.

C. Submittals
1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
   a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
      1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
      2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
   b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.
8. Other Informational Submittals:
   a. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
   b. Startup service reports.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

5. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.
6. UL Compliance: Test boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty
1. Special Warranty for Finned Water-Tube Boilers: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Heat Exchangers: 20 years from date of Substantial Completion.
   b. Warranty Period for Vent Dampers: Five years from date of Substantial Completion.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner: Five years from date of Substantial Completion, pro rata.
   b. Warranty Period for Pressure Vessel: 20 years from date of Substantial Completion, for thermal shock.

1.2 PRODUCTS

A. Finned Water-Tube Boilers
1. Description: Factory-fabricated, -assembled, and -tested boiler with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air intake connections, water supply and return connections, and controls.
2. Heat Exchanger:
   a. Finned copper **OR** steel **OR** copper-nickel, **as directed**, tubing with stainless-steel baffles.
   b. Bronze **OR** Cast-iron **OR** Steel, **as directed**, headers.
   c. Single-pass **OR** Two-pass, **as directed**, horizontal **OR** vertical **OR** coil, **as directed**, configuration.
   d. Tubes shall be sealed in header with silicone O-ring gaskets **OR** by welding **OR** by mechanically rolling tubes in header, **as directed**.
3. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures to 2000 deg F (1100 deg C).
4. Casing:
   a. Jacket: Sheet metal **OR** Stainless steel, **as directed**, with snap-in or interlocking closures.
   b. Control Compartment Enclosure: NEMA 250, Type 1A.
   c. Finish: Baked enamel over primer **OR** Baked enamel over galvanizing **OR** Powder coated, **as directed**.
   d. Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
   e. Draft Hood: Integral **OR** External, **as directed**.
   f. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
   g. Mounting base to secure boiler with accessory for mounting on combustible surface, **as directed**.
      1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And

Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

5. Burner:
   a. Burner Tubes and Orifices: Stainless steel, for natural **OR** propane, **as directed**, gas. Mount burner tubes in a slide-out burner drawer for ease of inspection, **as directed**.
      1) Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
      2) Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.
   b. Vertical Burner:
      1) High-temperature stainless steel **OR** Ceramic, **as directed**, to fire in a 360-degree pattern.
      2) Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply room **OR** outside, **as directed**, air through a replaceable 99 percent efficient (1-micrometer particles) filter, **as directed**, to boiler burner.
      3) Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.
   c. Gas Train for Commercial Boilers: Control devices and full-modulation **OR** on-off **OR** low-high-low **OR** proportional, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.
   d. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
   e. Pilot: Standing **OR** Intermittent-electric-spark **OR** Hot-surface, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
   f. Flue-Gas Recirculation Fans: Centrifugal fans on burner assembly to recirculate flue gas to decrease oxides of nitrogen emissions to less than 30 ppm.

   g. Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
6. Trim:
   a. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
   b. Safety Relief Valve: ASME rated.
   c. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
   d. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
   e. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
   f. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.
7. Controls:
   a. Refer to Division 15 Section "Hvac Instrumentation And Controls".
      OR
      Boiler operating controls shall include the following devices and features:
      1) Control transformer.
      2) Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
      3) Set-Point Adjust: Set points shall be adjustable.
      4) Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
         OR

Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).

5) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

b. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1) High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature.

2) Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.

3) Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.

4) Rollout Safety Switch: Factory mounted on boiler combustion chamber.

5) Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

c. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.

2) Control: On/off operation, hot water supply temperature set-point adjustment, **as directed**.

3) A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

B. Steel **OR** Flexible, **as directed**, Water-Tube Boilers

1. Description: Factory-fabricated and assembled **OR** Field-assembled, **as directed**, water-tube boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.

2. Heat-Exchanger Design: Straight steel tubes rolled into steel headers.

a. Accessible head plates at both ends.

b. Handholes or couplings, **as directed**, in headers for water-side inspections.

c. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.

d. Lifting lugs on top of boiler.

e. Built-in air separator.

3. Heat-Exchanger Design: Bent steel tubes swaged **OR** welded, **as directed**, into steel headers with membrane waterwall design, **as directed**.

a. Limit tube configurations to two **OR** four, **as directed**.

b. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.

c. Accessible inspection ports in drum, mud legs, and tube manifolds.

d. Lifting lugs on top of boiler.

e. Built-in air separator.

4. Combustion Chamber: Equipped with minimum 2-1/2-inch (64-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, 2700 deg F (1482 deg C) poured refractory on floor and minimum 2-inch (50-mm) **OR** 3-1/2-inch (89-mm), **as directed**, lap-jointed cast refractory with fiber-blanket joint seals on side walls. Combustion chamber shall have flame observation ports in front and back **OR** back, **as directed**.

5. Casing:

a. Insulation: Minimum 2-inch (50-mm) thick, lightweight refractory; 1-inch (25-mm) thick insulating board; galvanized-steel membrane, and 2-inch (50-mm) thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber **OR** 2-inch (50-mm)

thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber, **as directed**.

b. Top Flue Connection: Constructed of aluminized steel **OR** stainless steel, **as directed**.

c. Jacket: Mirror-finish stainless steel, with screw-fastened closures.
OR
Jacket: Sheet metal **OR** Galvanized sheet metal, **as directed**, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.

d. Mounting base to secure boiler to concrete base.

1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

e. Control Compartment Enclosure: NEMA 250, Type 1A.

6. Draft Diverter **OR** Barometric Damper, **as directed**: Galvanized-steel assembly with flue-gas thermometer.

7. Burner - Atmospheric Gas Burners:

a. Burner and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.

b. Gas Train for Commercial Boilers: Control devices and full-modulation **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.

c. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.

d. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

8. Burner - Forced-Draft Gas Burners:

a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.

b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1) Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

c. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.

d. Pilot: Intermittent **OR** Interrupted, **as directed**,-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

e. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.

1) Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.

9. Burner - Oil Burners:

a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.

b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1) Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

c. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.

1) Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
2) Oil Piping Specialties:
a) Suction-line, manual, gate valve.
b) Removable-mesh oil strainer.
c) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
d) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
e) Nozzle-line, solenoid-safety-shutoff oil valve.

d. Pilot: Intermittent **OR** Interrupted, **as directed**,-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid using cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.

e. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
1) Maximum Oxides of Nitrogen Emissions: 30 ppm.

10. Burner - Combination Gas and Oil Burners:

a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed** gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.

b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
1) Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

c. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI, **as directed**.
1) Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
2) Oil Piping Specialties:
a) Suction-line, manual, gate valve.
b) Removable-mesh oil strainer.
c) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
d) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
e) Nozzle-line, solenoid-safety-shutoff oil valve.

d. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.

e. Gas Pilot: Intermittent **OR** Interrupted, **as directed**,-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

f. Oil Pilot: Intermittent **OR** Interrupted, **as directed**,-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.

g. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
1) Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.

11. Trim for Hot-Water Boilers:

a. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.

b. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.

c. Safety Relief Valve: ASME rated.

d. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
e. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
f. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
g. Tankless Heater: Carbon-steel **OR** Bronze, **as directed**, header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
1) Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
2) Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

12. Trim for Steam Boilers:
a. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
b. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
c. Safety Relief Valve:
1) Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
2) Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
a) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
d. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
e. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
f. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.
g. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
h. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
i. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
j. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
1) Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
2) Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

13. Controls:
a. Refer to Division 15 Section "Hvac Instrumentation And Controls".
OR
Boiler operating controls shall include the following devices and features:
1) Control transformer.
2) Set-Point Adjust: Set points shall be adjustable.
3) Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
4) Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.

5) Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
OR
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).

6) Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.

7) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

b. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1) High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler or design pressure for steam boiler.

2) Low-Water Cutoff Switch: Electronic (for hot-water boilers) or Float and electronic (for steam boilers) probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**,-reset type.

3) Blocked Vent Safety Switch (Atmospheric Boilers): Manual-reset switch factory mounted on draft diverter.

4) Rollout Safety Switch (Atmospheric Boilers): Factory mounted on boiler combustion chamber.

5) Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

c. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.

2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.

3) A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

C. Electrical Power

1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 15.
OR
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

a. House in NEMA 250, Type 1 enclosure.

b. Wiring shall be numbered and color-coded to match wiring diagram.

c. Install factory wiring outside of an enclosure in a metal, **as directed**, raceway.

d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.

e. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker, **as directed**.

f. Provide each motor with overcurrent protection.

D. Venting Kits
1. Vent Damper (for Finned Water-Tube Boilers): Motorized, UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless-steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.
2. Kit: Complete system, ASTM A 959, Type 29-4C, **as directed**, stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.
3. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

E. Source Quality Control
1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
2. Burner and Hydrostatic Test (for Factory-Assembled Boilers): Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
3. Allow Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

1.3 EXECUTION

A. Boiler Installation
1. Install boilers level on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 02.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
4. Install oil-fired boilers according to NFPA 31.
5. Assemble boiler tubes in sequence and seal each tube joint.
6. Assemble and install boiler trim.
7. Install electrical devices furnished with boiler but not specified to be factory mounted.
8. Install control wiring to field-mounted electrical devices.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
4. Connect oil piping full size to burner inlet with shutoff valve and union.
5. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
7. Install piping from safety relief valves to nearest floor drain (for hot-water boilers).
8. Install piping from safety valves to drip-pan elbow and to nearest floor drain (for steam boilers).
9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
10. Boiler Flue Venting (for Finned Water-Tube Boilers):
    a. Install venting kit and combustion-air intake.

b. Connect full size to boiler connections. Comply with requirements in Division 15 Section "Breechings, Chimneys, And Stacks".

11. Connect breeching to full size of boiler outlet. Comply with requirements in Division 15 Section "Breechings, Chimneys, And Stacks" for venting materials.
12. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 15 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
13. Ground equipment according to Division 16 Section "Grounding And Bonding".
14. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Perform installation and startup checks according to manufacturer's written instructions.
   b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
   c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      1) Burner Test (for Field-Assembled Boilers): Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
      2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature **OR** steam pressure, **as directed**.
      3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Remove and replace malfunctioning units and retest as specified above.
4. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
5. Performance Tests, as directed:
   a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
   b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
   c. Perform field performance tests to determine the capacity and efficiency of the boilers.
      1) For dual-fuel boilers, perform tests for each fuel.
      2) Test for full capacity.
      3) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40 and 20, **as directed**, percent of full capacity. Determine efficiency at each test point.
   d. Repeat tests until results comply with requirements indicated.
   e. Provide analysis equipment required to determine performance.
   f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
   g. Notify the Owner in advance of test dates.
   h. Document test results in a report and submit to the Owner.

D. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 15624a

Task	Specification	Specification Description
15639	15061g	Steam And Condensate Piping

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SECTION 15642 - FEEDWATER EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for feedwater equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Feedwater pumps and receivers.
b. Vacuum-type feedwater pumps and receivers.

C. Definition
1. NPSH: Net-positive suction head.

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacity, temperature and NPSH required, pump performance curves with selection points clearly indicated, and furnished specialties and accessories.
2. Shop Drawings: Include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, method of field assembly, and attachments to other work.
a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that feedwater equipment, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and Maintenance Data.

E. Quality Assurance
1. Regulatory Requirements: Fabricate and test unit according to ASME PTC 12.1, "Closed Feedwater Heaters."
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. ASME Compliance: ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa); ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa). Safety valves and pressure vessels shall bear the appropriate ASME label.

F. Delivery, Storage, And Handling
1. Preparation for Shipping: Clean flanges and exposed-metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store units in dry location.
3. Retain protective flange covers and machined-surface protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with manufacturer's written rigging instructions.

1.2 PRODUCTS

A. Feedwater Units

1. Description: Factory-assembled and -tested unit consisting of a receiver, simplex **OR** duplex, **as directed**, feedwater pumps, controls, and the following features and accessories:
   a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
   b. Level gage glass, reflex flat type, **as directed**, with stops at top and bottom.
   c. Lifting eyes.
   d. Companion flanges.
   e. Pump, suction and discharge isolation valve, inlet strainer, discharge check valve, and liquid-filled pressure gage.
   f. Makeup Water Assembly: Float operated with integral valve **OR** Electric level controller and valve, **as directed**; with inlet strainer and three-valve bypass.
   g. Feedwater Heater: Sparge tube, thermostat, and control valve.
   h. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
      1) Cast-Iron Threaded Fittings: ASME B16.4; Class 125 **OR** 250, **as directed**.
      2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
      3) Forged-Steel Fittings: ASME B16.11, Class 3000.
      4) Malleable-Iron Unions: ASME B16.39; Class 150 **OR** 300, **as directed**.
      5) Forged-Steel Unions: MSS SP-83, Class 3000.
   i. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
      1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
      2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
2. Receiver:
   a. Material: Close-grain cast iron **OR** Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
   b. Additional corrosion protection:
      1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed,** thickness allowance.
      2) Electrolytic corrosion-inhibitor anode.
   c. Finish: Primer **OR** Primer under enamel topcoat **OR** Primer under epoxy topcoat, **as directed**.
   d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
   e. Mounting Arrangement: Recessed below floor **OR** Floor mounted, **as directed**.
   f. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor, **as directed**.
3. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze **OR** Stainless steel, **as directed**.
   b. Seals: Mechanical.
   c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
4. Horizontal Feedwater Pump: Base-mounted, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze **OR** Stainless steel, **as directed**.

b. Coupling: Close **OR** Flexible, **as directed**.
c. Seals: Mechanical.
d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

5. Control panel shall be unit mounted and factory wired and include the following:
   a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
   b. Single-point field power interface to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
      1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
   c. NEMA-rated motor controller for each motor, and include a hand-off-auto switch and overcurrent protection.
      1) Alternating controls for duplex units with intermittent operation as indicated by control sequence.
   d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
   e. Wiring outside of an enclosure in a metal, **as directed**, raceway. Make connections to motor with liquidtight conduit.
   f. Removable control mounting plate.
   g. Visual indication of status and alarm with momentary test push button, **as directed**.
   h. Audible alarm and silence switch.
   i. Visual indication of elapsed run time, graduated in hours.
   j. Fused control-circuit transformer.
   k. Microprocessor-based controller.
6. Feedwater Simplex-Pump Control Sequence:
   a. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
   b. Visual indication of pump on and off, **as directed**, status.
   c. Visual and audible, **as directed**, alarm indication of pump failure.
7. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with operating and standby pump):
   a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
   b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
   c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
   d. Visual indication of pump on and off, **as directed**, status.
   e. Visual indication of pump lead/lag status.
   f. Visual and audible, **as directed**, alarm indication of pump failure.
8. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with continuous pump operation and modulating control valve):
   a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
   b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
   c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
   d. Lead pump failure automatically starts lag pump.
      OR
      Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
   e. Visual indication of pump on and off, **as directed**, status.
   f. Visual indication of pump lead/lag status.
   g. Visual and audible, **as directed**, alarm indication of pump failure.
9. Receiver Makeup Water Control Sequence:
   a. Electric level controller operates electric control valve to maintain receiver water-level set point.
      OR

Mechanical float operates integral valve to maintain water-level set point.

b. Visual and audible, **as directed**, alarm indication of low and high, **as directed**, receiver-water level.

10. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.

a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, receiver low-water-level alarm, receiver high-water-level alarm, feedwater temperature, **as directed**.

B. Feedwater Unit With Vacuum Producer

1. Description: Receiver mounted, consisting of multijet vacuum producer, centrifugal pump and motor assembly mounted on separation chamber, and automatic pressure and water temperature controls. Include the following accessories:

a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.

b. Vacuum Gage: Dial-type register in inches of mercury (kPa).

c. Level Gage Glass: Stops top and bottom.

d. Air-suction check valve.

e. Lifting eyes.

f. Companion flanges.

g. Low-water cutoff switch.

h. Cooling-Water Control: Aquastat, inlet strainer, and electric valve.

i. Air vent.

j. Overflow drain from vacuum-producer receiver.

k. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.

1) Cast-Iron Threaded Fittings: ASME B16.4; Class 125 **OR** 250, **as directed**.

2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.

3) Forged-Steel Fittings: ASME B16.11, Class 3000.

4) Malleable-Iron Unions: ASME B16.39; Class 150 **OR** 300, **as directed**.

5) Forged-Steel Unions: MSS SP-83, Class 3000.

l. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.

1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.

2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.

2. Vacuum-Producer Reservoir and Vacuum Receiver:

a. Material: Close-grain cast iron **OR** Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.

b. Additional corrosion protection:

1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed,** thickness allowance.

2) Electrolytic corrosion-inhibitor anode.

c. Finish: Primer **OR** Primer under enamel topcoat **OR** Primer under epoxy topcoat, **as directed**.

d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.

e. Mounting Arrangement: Recessed below floor **OR** Floor mounted, **as directed**.

f. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor, **as directed**.

3. Vertical Vacuum-Producer Pump: Flange-mounted, close-coupled, single-stage, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze.
   b. Shaft: Stainless steel.
   c. Seals: Mechanical.
   d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
4. Horizontal Vacuum-Producer Pump: Base-mounted, single-stage, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze.
   b. Shaft: Stainless steel.
   c. Coupling: Close **OR** Flexible, **as directed**.
   d. Seals: Mechanical.
   e. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
5. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze **OR** Stainless steel, **as directed**.
   b. Seals: Mechanical.
   c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
6. Horizontal Feedwater Pump: Base-mounted, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of at least 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze **OR** Stainless steel, **as directed**.
   b. Coupling: Close **OR** Flexible, **as directed**.
   c. Seals: Mechanical.
   d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
7. Control panel shall be unit mounted and factory wired and include the following:
   a. Vacuum Switches for Simplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set to operate pump between 3 and 6 inches of mercury (10.1 and 20.2 kPa).
      OR
      Vacuum Switches for Duplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set so one pump operates for 3 to 5 inches of mercury (10.1 to 16.9 kPa) and both pumps operate for 4 to 6 inches of mercury (13.5 to 20.2 kPa).
   b. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
   c. Single-point field power interface to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
      1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
   d. NEMA-rated motor controller for each motor and include a hand-off-auto switch and overcurrent protection.
      1) Alternating control for units with intermittent operation as indicated by control sequence.
   e. Terminal blocks with numbered and color-coded wiring to match wiring diagram.

f. Wiring outside of an enclosure in a metal, **as directed**, raceway. Make connections to motor with liquidtight conduit.
g. Removable control mounting plate.
h. Visual indication of status and alarm with momentary test push button, **as directed**.
i. Audible alarm and silence switch.
j. Visual indication of elapsed run time, graduated in hours.
k. Fused control-circuit transformer.

8. Vacuum-Producer Control Sequence:
   a. Cycle pumps to maintain vacuum-pressure set point.
   b. Visual indication of pump on and off, **as directed**, status.
   c. Visual and audible, **as directed**, alarm indication of pump failure.
9. Feedwater Simplex-Pump Control Sequence:
   a. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
   b. Visual indication of pump on and off, **as directed**, status.
   c. Visual and audible, **as directed**, alarm indication of pump failure.
10. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with operating and standby pump):
    a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
    b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
    c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
    d. Visual indication of pump on and off, **as directed**, status.
    e. Visual indication of pump lead/lag status.
    f. Visual and audible, **as directed**, alarm indication of pump failure.
11. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with continuous pump operation and modulating control valve):
    a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
    b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
    c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
    d. Lead pump failure automatically starts lag pump.
       OR
       Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
    e. Visual indication of pump on and off, **as directed**, status.
    f. Visual indication of pump lead/lag status.
    g. Visual and audible, **as directed**, alarm indication of pump failure.
12. Makeup Water Control Sequence:
    a. Electric level controller operates electric control valve to maintain water temperature set point.
    b. Visual and audible, **as directed**, alarm indication of low and high, **as directed**, water level.
13. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
    a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, receiver low-water-level alarm, receiver high-water-level alarm, feedwater temperature, **as directed**.

1.3 EXECUTION

A. Installation

1. Install feedwater unit level on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 02.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install unit to permit access for maintenance.
4. Support piping independent of pumps.
5. Install base-mounted pumps on concrete bases with grouted base frames.
6. Install parts and accessories shipped loose.
7. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
8. Install piping adjacent to machine to allow service and maintenance.
9. Connect makeup water piping and cooling-water piping with reduced-pressure backflow preventers.
10. Install overflow drain piping to nearest floor drain.
11. Install vents and extend to outdoors; terminate with elbow turned down and an insect screen.
12. Adjust boiler water-level controls to properly stage unit.
13. Set field-adjustable, makeup water and cooling-water controls.
14. Clean equipment internally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions.
15. Clean strainers.

B. Field Quality Control
1. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with manufacturer's written instructions.
   b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   c. Check bearing lubrication.
   d. Verify proper motor rotation.
   e. Start up service.
   f. Report results in writing.
3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 15642

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SECTION 15642a - DEAERATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for deaerators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged, factory-assembled deaerators.

C. Definitions
1. Feedwater Pump: Pump that moves feedwater from the deaerator to the boiler.
2. Transfer Pump: Pump that moves feedwater from the surge tank to the deaerator.
3. NPSH: Net-positive suction head.

D. Submittals
1. Product Data: For each type of product indicated. Include rated makeup water, feedwater, and steam flow rates; working pressure; tank capacities; storage capacity in minutes; temperature and NPSH required; pump performance curves with selection points clearly indicated; furnished specialties; and accessories.
2. Shop Drawings: For deaerators, signed and sealed by a qualified professional engineer; include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, and attachments to other work.
   a. For installed products indicated to comply with design loads, include structural analysis data.
   b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing deaerator bases.
   c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that deaerators, accessories, and components will withstand seismic forces as indicated in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and Maintenance Data: For deaerators to include in emergency, operation, and maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa); ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa). Safety valves and pressure vessels shall bear the appropriate ASME label.

F. Delivery, Storage, And Handling
1. Protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping and storage.
2. Comply with manufacturer's written rigging instructions.
3. Deliver deaerators as factory-assembled units with protective crating and covering.

1.2 PRODUCTS

A. Manufactured Units

1. Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, single-compartment deaerator, and a separate packaged surge tank with transfer and feedwater pumps and controls to supply feedwater to deaerator, **as directed**.

   OR

   Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, two-compartment deaerator. One compartment for deaeration and one for surge volume, each with its own transfer and feedwater pumps and controls.

   OR

   Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, single-compartment deaerator and separate surge tank, both mounted on same factory-fabricated stand with necessary transfer and feedwater pumps and controls.
2. Material for Wetted Components: Components in contact with water that has not been deaerated shall be made of Type 304 **OR** 316, **as directed**, stainless steel.
3. Adjustable Spray Valves: Type 316 stainless steel. Arrange spray valves for counterflow of steam and condensate and so corrosive gases being vented do not contact deaerator's head or shell.
4. Vent Condenser: Stainless steel, with automatic and manual vent valves.
5. Deaerator and Storage Tank:
   a. Material: Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
   b. Additional Corrosion Protection:
      1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed**, thickness allowance.
      2) Electrolytic corrosion-inhibitor anode.
   c. Access: Manhole in deaerator and storage tank for access to internal components for inspection and service.
   d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm), **as directed,** for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
   e. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
      1) Cast-Iron Threaded Fittings: ASME B16.4, Class 125 **OR** 250, **as directed**.
      2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
      3) Forged-Steel Fittings: ASME B16.11, Class 3000.
      4) Malleable-Iron Unions: ASME B16.39, Class 150 **OR** 300, **as directed**.
      5) Forged-Steel Unions: MSS SP-83, Class 3000.
   f. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
      1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
      2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
6. Accessories:
   a. Lifting eyes.
   b. Companion flanges.
   c. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
   d. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**.
   e. Pump-discharge bypass relief valve **OR** orifice plate **OR** relief valve with orifice plate, **as directed**.

f. Makeup Water Assembly:
   1) Factory-mounted modulating valve with mechanical level control, external float cage, and stainless-steel float.
      OR
      Factory **OR** Field, **as directed**,-mounted, electric, pilot-operated, solenoid **OR** modulating, **as directed**, valve with factory-mounted, probe-type, **as directed**, water-level controller.
      OR
      Factory **OR** Field, **as directed**,-mounted, pneumatic modulating valve with factory-mounted water-level controller.
   2) Factory **OR** Field, **as directed**,-mounted, three-valve bypass and inlet strainer.

g. Steam Pressure-Reducing Valve(s): Steam **OR** Electric **OR** Pneumatic, **as directed**, operated with three-valve bypass, **as directed**, and sized to reduce boiler outlet pressure to the deaerator design pressure.

h. Tank Overflow Drain: Sized to relieve full capacity at operating pressure.

i. Safety Valve(s): ASME labeled and sized to relieve full capacity of pressure-reducing valve.

j. Vents: Manual and automatic vent valves.

k. Vacuum breaker.

l. Meters and Gages:
   1) Full-height, water-level gage glass, reflex flat type, **as directed**, and stop valve set.
   2) Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**, mounted to measure temperature in storage and steam, **as directed**, section of tank.
   3) Pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**, mounted to measure pressure in steam section of tank.

m. Provision for chemical injection quill.

n. Chemical injection quill.

o. Sampling connection with valve.

p. Tank drain connection with valve.

q. Oxygen test kit.

7. Support Frame: Structural-steel frame for supporting tank and pumps. Weld or bolt to tank.
   a. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only, as directed.

8. Feedwater Pump: Cast-iron, flange **OR** base, **as directed**,-mounted volute; with bronze **OR** stainless-steel, **as directed**, multistage centrifugal **OR** turbine, **as directed**, impeller, renewable bronze case ring, and stainless-steel shaft.
   a. Seals: Mechanical, suitable for 250 deg F (121 deg C).
   b. Pump Motor: Vertical **OR** Horizontal, **as directed**, open dripproof **OR** totally enclosed **OR** totally enclosed fan-cooled, **as directed**, enclosure, close **OR** flexible, **as directed**, coupled to pump. Comply with requirements in Division 15 Section "Motors."

9. Feedwater Pump Control Panel: Factory mounted and wired and including the following:
   a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
   b. Single-point, field power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
      1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
   c. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.
      1) Alternating control as indicated by control sequence for each pump.
   d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
   e. Metal raceway **OR** Raceway, **as directed**, for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
   f. Removable control mounting plate.

g. Visual indication of status and alarm with momentary test push button, **as directed**.
h. Audible alarm and silence switch.
i. Visual indication of elapsed run time, graduated in hours.
j. Fusible, control-circuit transformer.
k. Microprocessor-based controller.

10. Feedwater Pump Start-Stop Control Sequence (for intermittent pump operation):
    a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
    b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
    c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
    d. Visual indication of pump on **OR** on and off, **as directed**, status.
    e. Visual indication of pump lead/lag status.
    f. Visual **OR** Visual and audible, **as directed**, alarm indication of pump failure.
11. Feedwater Pump Continuous Control Sequence (for continuous pump operation and modulating control valve):
    a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
    b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
    c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
    d. Lead pump failure automatically starts lag pump.
       OR
       Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
    e. Visual indication of pump on **OR** on and off, **as directed**, status.
    f. Visual indication of pump lead/lag status.
    g. Visual **OR** Visual and audible, **as directed**, alarm indication of pump failure.
12. Makeup Water Control Sequence:
    a. Electric level controller operates electric control valve to maintain tank water-level set point.
       OR
       Pneumatic level controller operates pneumatic control valve to maintain tank water-level set point.
       OR
       Mechanical float operates valve to maintain water-level set point.
    b. Visual **OR** Visual and audible, **as directed**, alarm indication of low **OR** low and high, **as directed**, tank water level.
13. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
    a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, low-water level alarm, high-water level alarm, feedwater temperature, **as directed**.

B. Surge Tank
1. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.
2. Accessories:
    a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
    b. Level gage glass, reflex flat type, **as directed**, with stops at top and bottom.
    c. Lifting eyes.
    d. Companion flanges.
    e. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
    f. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**.

g. Pump-discharge bypass relief valve **OR** orifice plate **OR** relief valve with orifice plate, **as directed**.

3. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
   a. Cast-Iron Threaded Fittings: ASME B16.4, Class 125 **OR** 250, **as directed**.
   b. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
   c. Forged-Steel Fittings: ASME B16.11, Class 3000.
   d. Malleable-Iron Unions: ASME B16.39, Class 150 **OR** 300, **as directed**.
   e. Forged-Steel Unions: MSS SP-83, Class 3000.
4. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
   a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
   b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
5. Tank:
   a. Material: Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
   b. Additional Corrosion Protection:
      1) 0.07-inch (1.8-mm) **OR** 0.13-inch (3.3-mm) **OR** 0.19-inch (4.8-mm), **as directed**, thickness allowance.
      2) Electrolytic corrosion-inhibitor anode.
   c. Access: Manhole in tank for access to internal components for inspection and service.
   d. Factory-Applied Insulation and Jacket: Minimum thickness of 2 inches (50 mm) for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
6. Support Frame: Structural-steel frame for supporting tank. Weld or bolt to tank.
   a. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
7. Transfer Pump: Vertical, flange-mounted, close-coupled, single-stage **OR** multistage, **as directed**, radially split-case centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze **OR** Stainless steel, **as directed**.
   b. Seals: Mechanical.
   c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
8. Transfer Pump: Horizontal, base-mounted, single-stage **OR** multistage, **as directed**, radially split-case centrifugal pump; rated for 175-psig (1205-kPa) minimum working pressure and a continuous water temperature of 225 deg F (107 deg C); with the following features:
   a. Impeller: Bronze **OR** Stainless steel, **as directed**.
   b. Coupling: Close **OR** Flexible, **as directed**.
   c. Seals: Mechanical.
   d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
9. Transfer Pump Control Panel: Factory mounted and wired and including the following:
   a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
   b. Single-point, field power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
      1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
   c. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.

1) Alternating control indicated by control sequence for each pump.

d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.

e. Metal raceway **OR** Raceway, **as directed**, for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.

f. Removable control mounting plate.

g. Visual indication of on/off status and pump failure alarm with momentary test push button, **as directed**.

h. Audible alarm and silence switch.

i. Visual indication of elapsed run time, graduated in hours.

j. Fusible, control-circuit transformer.

k. Microprocessor-based controller.

10. Transfer Pump Start-Stop Control Sequence: Deaerator water-level controller controls lead pump; alternator switches lead and lag pump(s) after each start **OR** to equalize run time, **as directed**; failure of lead pump switches to lag pump and sounds audible alarm, **as directed**.

11. Transfer Pump Continuous-Run Control Sequence: Lead pump runs continuously while deaerator is operating; deaerator water-level controller modulates water-level-control valve; lead and lag pump(s) switch to equalize run time; lag pump operates if lead pump fails; pump failure sounds audible alarm, **as directed**.

12. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.

a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, low-water level alarm, high-water level alarm, **as directed**.

C. Factory Finishes

1. Manufacturer's standard prime-coat finish ready for field painting.
2. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.
3. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

D. Source Quality Control

1. Fabricate and label deaerator tanks according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
2. Factory install and test piping that connects pumps to tanks according to ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**.
3. Factory test performance and certify test results on packaged deaerator units, according to ASME PTC 12.3, before shipping to Project.

1.3 EXECUTION

A. Examination

1. Before deaerator installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance, maintenance, and operations.

a. Final deaerator locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

b. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Install deaerators level on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 02.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of 0.25 inch (6.35 mm). Vibration isolation devices and installation requirements are

specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

3. Install deaerators to permit access for service and maintenance.
4. Support piping independent of pumps.
5. Install base-mounted pumps on concrete base with grouted base frame.
6. Install all parts and materials not factory installed.
7. Extend overflow drains to floor drains.
8. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.
9. Install piping adjacent to machine to allow service and maintenance.

C. Connections
1. Steam and condensate piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect steam and condensate piping to tank tappings with shutoff valves and unions or flanges at each connection.
3. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.

D. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
   a. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
   b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   c. Verify bearing lubrication.
   d. Verify proper motor rotation.
   e. Test Reports: Prepare a written report to record the following:
      1) Test procedures used.
      2) Test results that comply with requirements.
      3) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
3. Remove and replace malfunctioning equipment and retest as specified above.

E. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
2. Complete installation and startup checks according to manufacturer's written instructions and do the following:
   a. Set deaerator makeup water-level controls.
   b. Verify bearing lubrication.
   c. Verify proper motor rotation.
   d. Start pumps according to manufacturer's written instructions.

F. Adjusting And Cleaning
1. Adjust initial temperature and pressure set points.
2. Set field-adjustable switches and circuit-breaker trip ranges.
3. Clean strainers.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain deaerators.

END OF SECTION 15642a

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SECTION 15655 - CENTRIFUGAL WATER CHILLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for centrifugal water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
b. Packaged, portable refrigerant recovery units.
c. Heat-exchanger, brush-cleaning system.

C. Definitions
1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
4. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
5. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.
6. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements
1. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) **OR** 55 deg F (13 deg C) **OR** 40 deg F (4 deg C), **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C) **OR** 60 deg F (16 deg C) **OR** 55 deg F (13 deg C), **as directed**.
c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 550/590, **as directed**:
a. Allowable Capacity Tolerance: Zero percent.
b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals

1. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance
1. ARI Certification: Certify chiller according to ARI 550 certification program.
2. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.
3. ASHRAE Compliance:
   a. ASHRAE 15 for safety code for mechanical refrigeration.
   b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
4. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
5. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.
6. Comply with NFPA 70.
7. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
8. Green Seal Compliance: Signed by manufacturer **OR** Green Seal, **as directed**, certifying compliance with GS-31.

G. Delivery, Storage, And Handling
1. Ship chillers from the factory fully charged with refrigerant.
   OR
   Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
2. Ship each oil-lubricated chiller with a full charge of oil.
   a. Ship oil factory installed in chiller **OR** in containers separate from chiller, **as directed**.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
   a. Extended warranties include, but are not limited to, the following:
      1) Complete chiller including refrigerant and oil charge.
         OR

Complete compressor and drive assembly including refrigerant and oil charge.
OR
Refrigerant **OR** Refrigerant and oil, **as directed**, charge.

2) Parts only **OR** Parts and labor, **as directed**.
3) Loss of refrigerant charge for any reason.

b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Unit
1. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, evaporator **OR** lubrication system evaporator, **as directed**, condenser, heat-reclaim condenser as indicated, controls, interconnecting unit piping and wiring, and indicated accessories.
   a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
   b. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.
2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

B. Compressor-Drive Assembly
1. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.
   a. Where indicated, provide oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.
2. Compressor:
   a. Casing: Cast iron, precision ground.
   b. Impeller: High-strength cast aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.
3. Drive: Direct-drive, hermetic **OR** Gear-drive, hermetic **OR** Gear-drive, open **OR** Direct- or gear-drive, hermetic **OR** Direct- or gear-drive, open or hermetic, **as directed**, design using an electric motor as the driver.
   a. Gear Drives: For chillers with gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards.
   b. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
   c. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
   a. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
   b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
   c. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
   d. For chillers with open drives, provide motor with open-dripproof **OR** weather-protected, Type I **OR** weather-protected, Type II **OR** totally enclosed, **as directed**, enclosure.
   e. Provide motor with thermistor or RTD in single motor winding **OR** each of three-phase motor windings, **as directed**, to monitor temperature and report information to chiller control panel.

f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.

5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
   a. Overspeed Test: 25 percent above design operating speed.
6. Service: Easily accessible for inspection and service.
   a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
   b. Provide lifting lugs or eyebolts attached to casing.
7. Economizers: For multistage chillers, provide interstage economizers.
8. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.
   a. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
   b. Operating Range: From 100 to 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
   c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) for each 10 percent in capacity reduction, **as directed**.
   d. Chillers with variable frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
9. Oil Lubrication System: Consisting of pump, filtration, heater, **as directed**, cooler, factory-wired power connection, and controls.
   a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, coastdown, and standby conditions including power failure.
   b. Manufacturer's standard method **OR** Thermostatically controlled oil heater properly sized, **as directed**, to remove refrigerant from oil.
   c. Oil filter **OR** Dual oil filers, one redundant, **as directed**, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
   d. Refrigerant **OR** Water, **as directed**,-cooled oil cooler.
   e. Factory-installed and pressure-tested piping with isolation valves and accessories.
   f. Oil compatible with refrigerant and chiller components.
   g. Positive visual indication of oil level.

C. Refrigeration
1. Refrigerant:
   a. Type: R-123; ASHRAE 34, Class B1 **OR** R-134a; ASHRAE 34, Class A1**,** as directed.
   b. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
2. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
3. Pressure Relief Device:
   a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   b. For Chillers Using R-123: Rupture disc constructed of frangible carbon **OR** Spring-loaded, pressure relief valve; single- or multiple-reseating type, **as directed**.
   c. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

4. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
5. Refrigerant Isolation for Chillers Using R-134a: Factory install positive shutoff, manual, **as directed**, isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell, **as directed**.
6. Purge System:
   a. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables including, but not limited to, water, water vapor, and noncondensable gases.
   b. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
   c. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
   d. Construct components of noncorrodible materials.
   e. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
   f. Efficiency of not more than 0.02 lb of refrigerant per pound of air (9 g of refrigerant per gram of air) when rated according to ARI 580.
   g. Operation independent of chiller per ASHRAE 147.
7. Positive-Pressure System:
   a. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic positive-pressure system.
   b. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than 0.5 psig (3 kPa) (adjustable) up to a pressure that remains within the vessel design pressure limits.
   c. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

D. Evaporator
1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent liquid refrigerant carryover from entering compressor.
4. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
5. Tubes:
   a. Individually replaceable from either end and without damage to tube sheets and other tubes.
   b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
   c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
   d. Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
   e. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   f. External Finish: Manufacturer's standard.
   g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

8. Water Box:
   a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
   c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
   d. Hinged **OR** Davited, **as directed**, water boxes.
      OR
      Hinged **OR** Davited, **as directed**, marine water-box covers.
   e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   f. Thermistor or RTD temperature sensor factory installed in each nozzle.
   g. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
9. Additional Corrosion Protection:
   a. Electrolytic corrosion-inhibitor anode.
   b. Coat wetted surfaces with a corrosion-resistant finish.
      OR
      Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

E. Condenser
1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
5. Tubes:
   a. Individually replaceable from either end and without damage to tube sheets and other tubes.
   b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
   c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
   d. Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**
   e. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   f. External Finish: Manufacturer's standard.
   g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Box:
   a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
   c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
   d. Hinged **OR** Davited, **as directed**, water boxes.
      OR

Hinged **OR** Davited, **as directed**, marine water-box covers.

e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.

f. Thermistor or RTD temperature sensor factory installed in each nozzle.

g. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

9. Additional Corrosion Protection:

a. Electrolytic corrosion-inhibitor anode.

b. Coat wetted surfaces with a corrosion-resistant finish.

OR

Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

F. Heat-Reclaim Condenser

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.

2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

4. Tubes:

a. Individually replaceable from either end and without damage to tube sheets and other tubes.

b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.

c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.

d. Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.

e. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.

f. External Finish: Manufacturer's standard.

g. Internal Finish: Enhanced **OR** Smooth, **as directed**.

5. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

7. Water Box:

a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.

b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.

c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.

d. Hinged **OR** Davited, **as directed**, water boxes.

OR

Hinged **OR** Davited, **as directed**, marine water-box covers.

e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.

f. Thermistor or RTD temperature sensor factory installed in each nozzle.

g. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

8. Additional Corrosion Protection:

a. Electrolytic corrosion-inhibitor anode.

b. Coat wetted surfaces with a corrosion-resistant finish.

OR

Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

G. Insulation
1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   a. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
2. Adhesive: As recommended by insulation manufacturer.
3. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
   a. Apply adhesive to 100 percent of insulation contact surface.
   b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
   c. Seal seams and joints to provide a vapor barrier.
   d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

H. Electrical
1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
   a. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
      1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
   b. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
   c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.
5. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.
   a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
   b. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
   c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
   d. Provide a ground terminal and a terminal block or individual connectors for phase connection.

I. Motor Controller

1. Enclosure: Factory installed, unit mounted **OR** Factory furnished, field mounted, **as directed**, NEMA 250 **OR** NEMA ICS 6, **as directed**, Type 1 **OR** Type 4 **OR** Type 4X **OR** Type 12, **as directed**, with hinged full-front access door with lock and key or padlock and key, **as directed**.
2. Control Circuit: Obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected control devices.
3. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
6. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
7. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
   a. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   b. Visual indication of motor and control status, including the following conditions:
      1) Controller on.
      2) Overload trip.
      3) Loss of phase.
      4) Starter fault.
8. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
   a. Externally Operated, Door-Interlocked, **as directed**, Disconnect: Fused disconnect switch **OR** Nonfused disconnect switch **OR** Circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
   b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
   c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
   d. Control Relays: Time-delay relays.
   e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
   f. Number-of-Starts Counter: Numerical readout on face of enclosure.
   g. Meters: Panel type, 2-1/2 inches (64 mm) **OR** 4-1/4 inches (108 mm), **as directed**, with 90 **OR** 120 **OR** 270, **as directed**,-degree scale and 1 **OR** 2, **as directed**, percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
      1) Ammeter: Output current for each phase, with current sensors rated to suit application.
      2) Voltmeter: Output voltage for each phase.
      3) Frequency Meter, **as directed**: Output frequency.
      4) Real-time clock with current time and date.
      5) Total run time.

      OR

      Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
      1) Selectable, digital display of the following:
         a) Phase Currents, Each Phase: Plus or minus 1 percent.
         b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
         c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
         d) Three-Phase Real Power: Plus or minus 2 percent.
         e) Three-Phase Reactive Power: Plus or minus 2 percent.
         f) Power Factor: Plus or minus 2 percent.
         g) Frequency: Plus or minus 0.5 percent.
         h) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.

i) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.

h. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.

i. Power Protection: Chiller shall shut down within six cycles of power interruption.

J. Variable Frequency Controller

1. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
2. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
3. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, with hinged full-front access door with lock and key.
4. Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
5. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
   a. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
   b. Regulator shall provide full digital control of frequency and voltage.
   c. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Operating Requirements:
   a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum, **as directed**.
   b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
   c. Capable of driving full load, without derating, under the following conditions:
      1) Ambient Temperature: 0 to 50 deg C.
      2) Relative Humidity: Up to 90 **OR** 95, **as directed**, percent (noncondensing).
      3) Altitude: 3300 feet (1005 m) **OR** 6600 feet (2010 m), **as directed**.
   d. Minimum Efficiency: 96 percent at 60 Hz, full load.
   e. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
   f. Overload Capability: 1.05 times the full-load current for 7 seconds.
   g. Starting Torque: As required by compressor-drive assembly.
   h. Speed Regulation: Plus or minus 1 percent.
   i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
   j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
   k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
9. Internal Adjustability Capabilities:
   a. Minimum Output Frequency: 6 Hz.
   b. Maximum Output Frequency: 60 Hz.
   c. Acceleration: 2 seconds to a minimum of 60 seconds.

d. Deceleration: 2 seconds to a minimum of 60 seconds.
e. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

10. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
    a. Overtemperature.
    b. Short circuit at controller output.
    c. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
    d. Open circuit at controller output.
    e. Input undervoltage.
    f. Input overvoltage.
    g. Loss of input phase.
    h. Reverse phase.
    i. AC line switching transients.
    j. Instantaneous overload, line to line or line to ground.
    k. Sustained overload exceeding 100 percent of controller rated current.
    l. Starting a rotating motor.
11. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
12. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
13. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
    a. Power on.
    b. Run.
    c. Overvoltage.
    d. Line fault.
    e. Overcurrent.
    f. External fault.
    g. Motor speed (percent).
    h. Fault or alarm status (code).
    i. DC-link voltage.
    j. Motor output voltage.
    k. Input kilovolt amperes.
    l. Total power factor.
    m. Input kilowatts.
    n. Input kilowatt-hours.
    o. Three-phase input voltage.
    p. Three-phase output voltage.
    q. Three-phase input current.
    r. Three-phase output current.
    s. Three-phase input voltage total harmonic distortion.
    t. Three-phase input current total harmonic distortion.
    u. Output frequency (Hertz).
    v. Elapsed operating time (hours).
    w. Diagnostic and service parameters.
14. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
15. Control Signal Interface:
    a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
16. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.
    OR
    Input Line Conditioning: <**Insert requirements**>.

17. Cooling: Air **OR** Refrigerant **OR** Water, **as directed**, cooled.
18. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
    a. Control Relays: Auxiliary and adjustable time-delay relays.
19. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

K. Controls
1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
    a. Date and time.
    b. Operating or alarm status.
    c. Fault history with not less than last 10 faults displayed.
    d. Set points of controllable parameters.
    e. Trend data.
    f. Operating hours.
    g. Number of chiller starts.
    h. Outdoor-air temperature or space temperature if required for chilled-water reset.
    i. Entering- and leaving-fluid temperatures of evaporator and condenser.
    j. Difference in fluid temperatures of evaporator and condenser.
    k. Fluid flow of evaporator and condenser.
    l. Fluid pressure drop of evaporator and condenser.
    m. Refrigerant pressures in evaporator and condenser.
    n. Refrigerant saturation temperature in evaporator and condenser shell.
    o. Compressor refrigerant suction and discharge temperature.
    p. Compressor bearing temperature.
    q. Motor bearing temperature.
    r. Motor winding temperature.
    s. Oil temperature.
    t. Oil discharge pressure.
    u. Phase current.
    v. Percent of motor rated load amperage.
    w. Phase voltage.
    x. Demand power (kilowatts).
    y. Energy use (kilowatt-hours).
    z. Power factor.
    aa. For chillers equipped with variable frequency controllers and harmonic filters, include the following:
        1) Output voltage and frequency.
        2) Voltage total harmonic distortion for each phase.
        3) Supply current total demand distortion for each phase.
        4) Inlet vane position.
        5) Controller internal ambient temperature.
        6) Heatsink temperature.
    bb. Purge suction temperature if purge system is provided.
    cc. Purge elapsed time if purge system is provided.
4. Control Functions:
    a. Manual or automatic startup and shutdown time schedule.

b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
c. Current limit and demand limit.
d. Condenser-fluid temperature.
e. External chiller emergency stop.
f. Variable evaporator flow.
g. Thermal storage.
h. Heat reclaim.

5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
   a. Low evaporator pressure **OR** temperature, **as directed**; high condenser pressure.
   b. Low evaporator fluid temperature.
   c. Low oil differential pressure.
   d. High or low oil pressure.
   e. High oil temperature.
   f. High compressor-discharge temperature.
   g. Loss of condenser-fluid flow.
   h. Loss of evaporator fluid flow.
   i. Motor overcurrent.
   j. Motor overvoltage.
   k. Motor undervoltage.
   l. Motor phase reversal.
   m. Motor phase failure.
   n. Sensor- or detection-circuit fault.
   o. Processor communication loss.
   p. Motor controller fault.
   q. Extended compressor surge.
   r. Excessive air-leakage detection for chillers using R-123 refrigerant.
6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
9. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
10. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    a. Hardwired Points:
       1) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours) **OR** power factor, **as directed**.
       2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

L. Finish
1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
c. Paint surfaces that are to be insulated before applying the insulation.
d. Paint installed insulation to match adjacent uninsulated surfaces.
e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner, **as directed**.

2. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

M. Accessories

1. Flow Switches:
   a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
   b. Paddle Flow Switches:
      1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
      2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
      3) Pressure rating equal to pressure rating of heat exchanger.
      4) Construct body and wetted parts of Type 316 stainless steel.
      5) House switch in a NEMA 250, Type 4, **as directed**, enclosure constructed of die-cast aluminum.
      6) Vane length to suit installation.

      OR

      Pressure Differential Switches:
      1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
      2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
      3) Set Point: Screw type, field adjustable.
      4) Electrical Connections: Internally mounted screw-type terminal blocks.
      5) Switch Enclosure: NEMA 250, Type 4, **as directed**.
      6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
2. Vibration Isolation:
   a. Chiller manufacturer shall furnish vibration isolation for each chiller.
   b. Neoprene Pad:
      1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
      2) Fabricate pads from 40- to 50-durometer neoprene.
      3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

      OR

      Spring Isolator:
      1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed so that the Kx/Ky ratio shall be 1.0 or more for stability.
      2) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
      3) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.

4) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
5) Isolators shall be selected for a nominal 1-inch (25-mm) **OR** 2-inch (50-mm), **as directed**, deflection.

3. Sound Barrier:
   a. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
   b. Provide for repeated installation and removal without use of tape or calk.
   c. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
   d. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
   e. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
   f. Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.
   g. Permanently label each section of cover to indicate its location, description, size, and number sequence.
   h. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

N. Packaged Refrigerant Recovery Units
1. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.

O. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
4. Components:
   a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
   b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
   c. Four-Way Valve:
      1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
      2) Configure valve with parallel flow connections to minimize field installation piping.
      3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
      4) Pipe connections shall be flanged.

5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
6) Hydrostatically test to 1.5 times the design working pressure.
7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
9) Valve Actuator: Mount electric actuator to operate valve.
OR
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
10) Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.

d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
3) Manual override of preset cleaning cycle.
4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
6) Flow switch bypass.
7) Unloading signal to chiller.

P. Source Quality Control
1. Perform functional **OR** functional run, **as directed**, tests of chillers before shipping.
2. Factory performance test chillers, before shipping, according to ARI 550/590.
a. Test the following conditions:
1) Design conditions indicated.
2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
OR
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
OR
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
b. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
3. Factory sound test chillers, before shipping, according to ARI 575, **s directed**.
a. Test the following conditions:
1) Design conditions indicated.
2) Chiller operating at calculated worst-case sound condition.
3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
b. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

4. For chillers using R-134a refrigerant, factory test and inspect evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
5. For chillers using R-123 refrigerant, factory test and inspect evaporator and condenser **OR** condenser and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of 45 psig (310 kPa). Vacuum and pressure test for leaks.
6. For chillers located indoors, rate sound power level according to ARI 575.

1.3 EXECUTION

A. Chiller Installation
1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Maintain manufacturer's recommended clearances for service and maintenance.
6. Charge chiller with refrigerant and fill with oil if not factory installed.
7. Install separate devices furnished by manufacturer and not factory installed.

B. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
3. Provide field electric power, as required, to each system control panel and electric actuated valve.
4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.

5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

C. Connections
1. Comply with requirements for piping specified in Division 15 Section(s) "Hydronic Piping" AND "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to chiller to allow service and maintenance.
3. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
4. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
5. Heat-Reclaim Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping **OR** separate vent piping for each chiller, **as directed** to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
7. For chillers equipped with a purge system, extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.
8. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
   c. Verify that pumps are installed and functional.
   d. Verify that thermometers and gages are installed.
   e. Operate chiller for run-in period.
   f. Check bearing lubrication and oil levels.
   g. Verify that refrigerant pressure relief device is vented outside.
   h. Verify proper motor rotation.
   i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
   j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**.
   k. Verify and record performance of chiller protection devices.
   l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

3. Prepare test and inspection startup reports.

END OF SECTION 15655

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SECTION 15655a - ROTARY-SCREW WATER CHILLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for rotary screw water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Packaged, water-cooled, single-compressor chillers.
b. Packaged, water-cooled, multiple-compressor chillers.
c. Packaged, air-cooled chillers.
d. Packaged, portable refrigerant recovery units.
e. Heat-exchanger, brush-cleaning system.

C. Definitions
1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
4. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
5. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW)at any given set of rating conditions.
6. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than ARI standard rating conditions.

D. Performance Requirements
1. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) **OR** 55 deg F (13 deg C) **OR** 40 deg F (4 deg C), **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C) **OR** 60 deg F (16 deg C) **OR** 55 deg F (13 deg C), **as directed**.
c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 550/590, **as directed**:
a. Allowable Capacity Tolerance: Zero percent.
b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals
1. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance
1. ARI Certification: Certify chiller according to ARI 550 and ARI 590, **as directed**, certification program(s).
2. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.
3. ASHRAE Compliance:
   a. ASHRAE 15 for safety code for mechanical refrigeration.
   b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
4. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
5. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
6. Comply with NFPA 70.
7. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

G. Delivery, Storage, And Handling
1. Ship chillers from the factory fully charged with refrigerant.
   OR
   Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
2. Ship each oil-lubricated chiller with a full charge of oil.
   a. Ship oil factory installed in chiller **OR** in containers separate from chiller, **as directed**.
3. Package chiller for export shipping in totally enclosed crate and bagging, **as directed**.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
   a. Extended warranties include, but are not limited to, the following:
      1) Complete chiller including refrigerant and oil charge.
         OR
         Complete compressor and drive assembly including refrigerant and oil charge.
         OR
         Refrigerant **OR** Refrigerant and oil charge, **as directed**.
      2) Parts only **OR** Parts and labor, **as directed**.
      3) Loss of refrigerant charge for any reason.
   b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Packaged, Water-Cooled, Single-Compressor Chillers

1. Description: Factory-assembled and factory-tested **OR** run-tested, **as directed**, chiller with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, heat-reclaim condenser as indicated, controls, interconnecting unit piping and wiring, and indicated accessories.
   a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
3. Compressor:
   a. Description: Hermetic **OR** Open, **as directed**, positive displacement, and oil lubricated.
   b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
   c. Rotors: Manufacturer's standard one-, two-, or three-rotor design.
   d. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
   e. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
   a. Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
   b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
   c. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
   d. For chillers with open drives, provide motor with open-dripproof **OR** weather-protected, Type I **OR** weather-protected, Type II **OR** totally enclosed, **as directed**, enclosure.
   e. Provide motor with thermistor or RTD in single motor winding **OR** each of three-phase motor windings, **as directed**, to monitor temperature and report information to chiller control panel.
   f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
   g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
   a. Overspeed Test: 25 percent above design operating speed.
6. Service: Easily accessible for inspection and service.
   a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
   b. Provide lifting lugs or eyebolts attached to casing.
7. Capacity Control: Modulating slide-valve assembly or port unloaders combined with a variable frequency controller, if applicable, and hot-gas bypass, if necessary, to achieve performance indicated.
   a. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
   b. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
   c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F1.4 deg C drop for each 10 percent in capacity reduction, **as directed**.
8. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
   a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
   b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.

c. Oil filter **OR** Dual oil filers, one redundant, **as directed**, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
d. Refrigerant **OR** Water, **as directed**,-cooled oil cooler.
e. Factory-installed and pressure-tested piping with isolation valves and accessories.
f. Oil compatible with refrigerant and chiller components.
g. Positive visual indication of oil level.

9. Refrigerant Circuit:
   a. Refrigerant: Type as indicated on Drawings.
      OR
      Refrigerant Type: R-22 **OR** R-134a **OR** HFC, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   c. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
   d. Pressure Relief Device:
      1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
      2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
   e. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
   f. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell, **as directed**.

10. Evaporator:
    a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
    b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
    c. Designed to prevent liquid refrigerant carryover from entering compressor.
    d. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
    e. Tubes:
       1) Individually replaceable from either end and without damage to tube sheets and other tubes.
       2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
       3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
       4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
       5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
       6) External Finish: Manufacturer's standard.
       7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
    f. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
    g. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

h. Water Box:
   1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
   3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
   4) Hinged **OR** Davited, **as directed**, water boxes.
      OR
      Hinged **OR** Davited, **as directed**, marine water-box covers.
   5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   6) Thermistor or RTD temperature sensor factory installed in each nozzle.
   7) Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

i. Additional Corrosion Protection:
   1) Electrolytic corrosion-inhibitor anode.
   2) Coat wetted surfaces with a corrosion-resistant finish.

11. Condenser:
   a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
   b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
   c. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
   d. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
   e. Tubes:
      1) Individually replaceable from either end and without damage to tube sheets and other tubes.
      2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
      3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
      4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
      5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
      6) External Finish: Manufacturer's standard.
      7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
   f. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
   g. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
   h. Water Box:
      1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
      2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
      3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
      4) Hinged **OR** Davited, **as directed**, water boxes.
         OR
         Hinged **OR** Davited, **as directed**, marine water-box covers.

5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
6) Thermistor or RTD temperature sensor factory installed in each nozzle.
7) Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

i. Additional Corrosion Protection:
1) Electrolytic corrosion-inhibitor anode.
2) Coat wetted surfaces with a corrosion-resistant finish.

12. Heat-Reclaim Condenser:
a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
c. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
d. Tubes:
1) Individually replaceable from either end and without damage to tube sheets and other tubes.
2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
6) External Finish: Manufacturer's standard.
7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
e. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
f. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
g. Water Box:
1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
4) Hinged **OR** Davited, **as directed**, water boxes.
OR
Hinged **OR** Davited, **as directed**, marine water-box covers.
5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
6) Thermistor or RTD temperature sensor factory installed in each nozzle.
7) Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
h. Additional Corrosion Protection:
1) Electrolytic corrosion-inhibitor anode.
2) Coat wetted surfaces with a corrosion-resistant finish.

13. Electrical Power:
a. Factory installed and wired, and functionally tested at factory before shipment.

b. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
   1) Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
   2) NEMA- and ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
   3) Control-circuit transformer with primary and secondary side fuses.

c. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

d. Factory-installed wiring outside of enclosures shall be in metal raceway except make connections to each motor and heater with not more than a 24-inch (610-mm) length of liquidtight conduit.

e. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.
   1) If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
   2) Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
   3) Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within 1 minute after de-energizing.
   4) Provide a ground terminal and a terminal block or individual connectors for phase connection.

14. Motor Controller:

a. Enclosure: Factory installed, unit mounted **OR** Factory furnished, field mounted, **as directed**, NEMA 250 **OR** NEMA ICS 6, **as directed**, Type 1 **OR** Type 4 **OR** Type 4X **OR** Type 12, **as directed**, with hinged full-front access door with lock and key or padlock and key, **as directed**.

b. Control Circuit: Obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected control devices.

c. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.

d. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.

e. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.

f. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.

g. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
   1) Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   2) Visual indication of motor and control status, including the following conditions:
      a) Controller on.
      b) Overload trip.
      c) Loss of phase.
      d) Starter fault.

h. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
   1) Externally Operated, Door-Interlocked, **as directed**, Disconnect: Fused disconnect switch **OR** Nonfused disconnect switch **OR** Circuit breaker, **as directed**. Minimum

withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.

2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
3) Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
4) Control Relays: Time-delay relays.
5) Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
6) Number-of-Starts Counter: Numerical readout on face of enclosure.
7) Meters: Panel type, 2-1/2 inches (64 mm) **OR** 4-1/4 inches (108 mm), **as directed**, with 90 **OR** 120 **OR** 270, **as directed**,-degree scale and 1 **OR** 2, **as directed**, percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
   a) Ammeter: Output current for each phase, with current sensors rated to suit application.
   b) Voltmeter: Output voltage for each phase.
   c) Frequency Meter: Output frequency.
   d) Real-time clock with current time and date.
   e) Total run time.

   OR

   Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   a) Selectable, digital display of the following:
      i. Phase Currents, Each Phase: Plus or minus 1 percent.
      ii. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      iii. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      iv. Three-Phase Real Power: Plus or minus 2 percent.
      v. Three-Phase Reactive Power: Plus or minus 2 percent.
      vi. Power Factor: Plus or minus 2 percent.
      vii. Frequency: Plus or minus 0.5 percent.
      viii. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
      ix. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
   b) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
8) Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
9) Power Protection: Chiller shall shut down within six cycles of power interruption.

15. Variable Frequency Controller:
   a. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
   b. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
   c. Enclosure: Unit mounted, NEMA 250, Type 1, **as directed**, with hinged full-front access door with lock and key.
   d. Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
   e. Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.

f. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

g. Operating Requirements:
   1) Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum, **as directed**.
   2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
   3) Capable of driving full load, without derating, under the following conditions:
      a) Ambient Temperature: 0 to 40 deg C.
      b) Relative Humidity: Up to 90 **OR** 95, **as directed**, percent (noncondensing).
      c) Altitude: 3300 feet (1005 m) **OR** 6600 feet (2010 m), **as directed**.
   4) Minimum Efficiency: 96 percent at 60 Hz, full load.
   5) Minimum Displacement Primary-Side Power Factor: 98 percent.
   6) Overload Capability: 1.05 times the full-load current for 7 seconds.
   7) Starting Torque: As required by compressor-drive assembly.
   8) Speed Regulation: Plus or minus 1 percent.
   9) Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
   10) To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
   11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

h. Internal Adjustability Capabilities:
   1) Minimum Output Frequency: 6 Hz.
   2) Maximum Output Frequency: 60 Hz.
   3) Acceleration: 2 seconds to 60 seconds.
   4) Deceleration: Zero seconds to 60 seconds.
   5) Current Limit: 30 to a minimum of 100 percent of maximum rating.

i. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
   1) Overtemperature.
   2) Short circuit at controller output.
   3) Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
   4) Open circuit at controller output.
   5) Input undervoltage.
   6) Input overvoltage.
   7) Loss of input-phase.
   8) Reverse phase.
   9) AC line switching transients.
   10) Instantaneous overload, line to line or line to ground.
   11) Sustained overload exceeding 100 percent of controller rated current.
   12) Starting a rotating motor.

j. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

k. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.

l. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
   1) Power on.
   2) Run.
   3) Overvoltage.
   4) Line fault.
   5) Overcurrent.

6) External fault.
7) Motor speed (percent).
8) Fault or alarm status (code).
9) Motor output voltage.
10) Input kilovolt amperes.
11) Total power factor.
12) Input kilowatts.
13) Input kilowatt-hours.
14) Three-phase input voltage.
15) Three-phase output voltage.
16) Three-phase input current.
17) Three-phase output current.
18) Output frequency (Hertz).
19) Elapsed operating time (hours).
20) Diagnostic and service parameters.

m. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

n. Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.

16. Controls:

a. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

b. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.

c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

1) Date and time.
2) Operating or alarm status.
3) Fault history with not less than last 10 faults displayed.
4) Set points of controllable parameters.
5) Trend data.
6) Operating hours.
7) Number of chiller starts.
8) Outdoor-air temperature or space temperature if required for chilled-water reset.
9) Temperature and pressure of operating set points.
10) Entering- and leaving-fluid temperatures of evaporator and condenser.
11) Difference in fluid temperatures of evaporator and condenser.
12) Fluid flow of evaporator and condenser.
13) Fluid pressure drop of evaporator and condenser.
14) Refrigerant pressures in evaporator and condenser.
15) Refrigerant saturation temperature in evaporator and condenser.
16) Pump status.
17) Antirecycling timer status.
18) Percent of maximum motor amperage.
19) Current-limit set point.
20) Compressor bearing temperature.
21) Motor bearing temperature.
22) Motor winding temperature.
23) Oil temperature.
24) Oil discharge pressure.
25) Phase current.
26) Percent of motor rated load amperes.
27) Phase voltage.

28) Demand power (kilowatts).
29) Energy use (kilowatt-hours).
30) Power factor.

d. Control Functions:
1) Manual or automatic startup and shutdown time schedule.
2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
3) Current limit and demand limit.
4) Condenser-fluid temperature.
5) External chiller emergency stop.
6) Antirecycling timer.
7) Variable evaporator flow.
8) Thermal storage.
9) Heat reclaim.

e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
1) Low evaporator pressure or temperature; high condenser pressure.
2) Low evaporator fluid temperature.
3) Low oil differential pressure.
4) High or low oil pressure.
5) High oil temperature.
6) High compressor-discharge temperature.
7) Loss of condenser-fluid flow.
8) Loss of evaporator-fluid flow.
9) Motor overcurrent.
10) Motor overvoltage.
11) Motor undervoltage.
12) Motor phase reversal.
13) Motor phase failure.
14) Sensor- or detection-circuit fault.
15) Processor communication loss.
16) Motor controller fault.
17) Extended compressor surge.

f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

i. Communication Port: RS-232 port or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.

j. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
1) Hardwired Points:
a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours) **OR** power factor, **as directed**.
b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

17. Insulation:
    a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
    b. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
    c. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
    d. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
        1) Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
        2) Seal seams and joints to provide a vapor barrier.
        3) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
18. Finish:
    a. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
        1) Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
        2) Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
        3) Paint surfaces that are to be insulated before applying the insulation.
        4) Paint installed insulation to match adjacent uninsulated surfaces.
        5) Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner, **as directed**.
    b. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.
19. Accessories:
    a. Flow Switches:
        1) If required and not factory installed, chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
        2) Paddle Flow Switches:
            a) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
            b) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
            c) Pressure rating equal to pressure rating of heat exchanger.
            d) Construct body and wetted parts of Type 316 stainless steel.
            e) House switch in a NEMA 250, Type 4, **as directed**, enclosure constructed of die-cast aluminum.
            f) Vane length to suit installation.

            OR

            Pressure Differential Switches:
            g) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
            h) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
            i) Set Point: Screw type, field adjustable.
            j) Electrical Connections: Internally mounted screw-type terminal blocks.
            k) Switch Enclosure: NEMA 250, Type 4, **as directed**.

l) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.

b. Vibration Isolation:

c. Chiller manufacturer shall furnish vibration isolation for each chiller.

1) Neoprene Pad:

a) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.

b) Fabricate pads from 40- to 50-durometer neoprene.

c) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

OR

Spring Isolator:

d) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed such that the Kx/Ky ratio shall be 1.0 or more for stability.

e) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.

f) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.

g) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.

h) Isolators shall be selected for a nominal 1-inch (25-mm) **OR** 2-inch (50-mm), **as directed**, deflection.

d. Sound Barrier:

1) Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.

2) Provide for repeated installation and removal without use of tape or calk.

3) Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.

4) Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.

5) Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.

6) Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.

7) Permanently label each section of cover to indicate its location, description, size, and number sequence.

8) Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

B. Packaged, Water-Cooled, Multiple-Compressor Chillers

1. Description: Factory-assembled and -tested **OR** run-tested, **as directed**, chiller with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.

a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.

2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
3. Compressors:
   a. Description: Positive displacement, hermetically sealed.
   b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
   c. Rotors: Manufacturer's standard one- or two-rotor design.
4. Service: Easily accessible for inspection and service.
   a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
   b. Provide lifting lugs or eyebolts attached to casing.
5. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
   a. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
   b. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
   c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) drop for each 10 percent in capacity reduction, **as directed**.
6. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
   a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
   b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
   c. Factory-installed and pressure-tested piping with isolation valves and accessories.
   d. Oil compatible with refrigerant and chiller components.
   e. Positive visual indication of oil level.
7. Vibration Control:
   a. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
      1) Overspeed Test: 25 percent above design operating speed.
   b. Isolation: Mount individual compressors on vibration isolators.
8. Sound Control: Sound-reduction package shall consist of removable acoustic enclosures around the compressors and drive assemblies that are designed to reduce sound levels without affecting performance.
9. Compressor Motors:
   a. Hermetically sealed and cooled by refrigerant suction gas.
   b. High-torque, induction type with inherent thermal-overload protection on each phase.
10. Refrigerant Circuits:
   a. Refrigerant: Type as indicated on Drawings.
      OR
      Refrigerant Type: R-22 **OR** R-134a **OR** HFC, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   c. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction, **as directed**, and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core, **as directed**, filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
   d. Pressure Relief Device:
      1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
      2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

e. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid-line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.

11. Evaporator:
    a. Description: Shell-and-tube design.
        1) Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
        2) Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
    b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    c. Shell Material: Carbon steel.
    d. Shell Heads: Removable carbon-steel heads with multipass baffles, and located at each end of the tube bundle.
    e. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
    f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
12. Condenser:
    a. Shell and tube, or without integral condenser; as indicated.
       OR
       Shell and Tube:
        1) Description: Shell-and-tube design with refrigerant flowing through shell, and fluid flowing through tubes within shell.
        2) Provides positive subcooling of liquid refrigerant.
        3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
        4) Shell Material: Carbon steel.
        5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
        6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
        7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
    b. Provide chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 15 Section "Air-cooled Condensers".
13. Electrical Power:
    a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint **OR** single-point, **as directed**, field-power connection to chiller.
    b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key, **as directed**.
    c. Wiring shall be numbered and color-coded, **as directed**, to match wiring diagram.
    d. Install factory wiring outside of an enclosure in a raceway.
    e. Field-power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch **OR** NEMA AB 1, instantaneous-trip circuit breaker with lockable handle, **as directed**.
        1) Disconnect means shall be interlocked with door operation.
        2) Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
    f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
        1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

g. Provide each motor with overcurrent protection.

h. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.

i. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.

j. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

k. Control Relays: Auxiliary and adjustable time-delay relays.

l. For chiller electrical power supply, indicate the following:

1) Current and phase to phase for all three phases.
2) Voltage, phase to phase, and phase to neutral for all three phases.
3) Three-phase real power (kilowatts).
4) Three-phase reactive power (kilovolt amperes reactive).
5) Power factor.
6) Running log of total power versus time (kilowatt-hours).
7) Fault log, with time and date of each.

14. Compressor Motor Controllers:

a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state, **as directed**.

b. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed or open transition, or solid state, **as directed**.

15. Controls:

a. Standalone and microprocessor based.

b. Enclosure: Share enclosure with electrical-power devices or provide a separate enclosure of matching construction.

c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:

1) Date and time.
2) Operating or alarm status.
3) Fault history with not less than last 10 faults displayed.
4) Set points of controllable parameters.
5) Trend data.
6) Operating hours.
7) Number of chiller starts.
8) Outdoor-air temperature or space temperature if required for chilled-water reset.
9) Temperature and pressure of operating set points.
10) Entering- and leaving-fluid temperatures of evaporator and condenser.
11) Difference in fluid temperatures of evaporator and condenser.
12) Refrigerant pressures in evaporator and condenser.
13) Refrigerant saturation temperature in evaporator and condenser.
14) No cooling load condition.
15) Elapsed time meter (compressor run status).
16) Pump status.
17) Antirecycling timer status.
18) Percent of maximum motor amperage.
19) Current-limit set point.
20) Number of compressor starts.
21) Compressor refrigerant suction and discharge temperature.
22) Oil temperature.
23) Oil discharge pressure.
24) Phase current.
25) Percent of motor rated load amperes.
26) Phase voltage.

d. Control Functions:
   1) Manual or automatic startup and shutdown time schedule.
   2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
   3) Current limit and demand limit.
   4) Condenser-fluid temperature.
   5) External chiller emergency stop.
   6) Antirecycling timer.
   7) Automatic lead-lag switching.
   8) Variable evaporator flow.
   9) Thermal storage.

e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
   1) Low evaporator pressure, or high condenser pressure.
   2) Low chilled-water temperature.
   3) Refrigerant high pressure.
   4) High or low oil pressure.
   5) High oil temperature.
   6) Loss of chilled-water flow.
   7) Loss of condenser-fluid flow.
   8) Control device failure.

f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

i. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
   1) Hardwired Points:
      a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours), **as directed**.
      b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
   2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

16. Insulation:
   a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
   b. Thickness: 3/4 inch (19 mm).
   c. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
   d. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
      1) Before insulating steel surfaces, prepare surfaces for paint, prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
      2) Seal seams and joints to provide a vapor barrier.

3) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

17. Finish:
    a. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
        1) Provide at least one coat of primer.
        2) Provide finish coat of alkyd-modified, vinyl enamel, **as directed**.
        3) Paint surfaces that are to be insulated before applying the insulation.
        4) Paint installed insulation to match adjacent uninsulated surfaces.
18. Accessories:
    a. Factory-furnished, chilled- and condenser-, **as directed**,water flow switches for field installation.
    b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
    c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.

C. Packaged, Air-Cooled Chillers
1. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
2. Fabricate base, frame, and attachment to chiller components strong enough to resist chiller movement during a seismic event when chiller base is anchored to field support structure.
3. Cabinet:
    a. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
    b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
    c. Casing: Galvanized steel.
    d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500 **OR** 1000, **as directed**,-hour salt-spray test according to ASTM B 117.
    e. Sound-reduction package designed to reduce sound level without affecting performance and consisting of the following:
        1) Acoustic enclosure around compressors.
        2) Reduced-speed fans with acoustic treatment.
    f. Security Package: Provide removable grilles **OR** louvered panels, **as directed**, with fasteners for additional protection of compressors, evaporator, and condenser coils without inhibiting service access. Finish to match cabinet.
4. Compressors:
    a. Description: Positive displacement, hermetically sealed.
    b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
    c. Rotors: Manufacturer's standard one- or two-rotor design.
    d. Each compressor provided with suction and, **as directed**, discharge shutoff valves, crankcase oil heater, and suction strainer.
5. Service: Easily accessible for inspection and service.
6. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.

7. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
    a. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
    b. Condenser-Air Unloading Requirements over Operating Range: Constant-design entering condenser-air temperature **OR** Drop-in entering condenser-air temperature of 5 deg F (3 deg C) drop for each 10 percent in capacity reduction, **as directed**.

c. For units equipped with a variable frequency controller, capacity control shall be both "valveless" and "stepless," requiring no slide valve or capacity-control valve(s) to operate at reduced capacity.

8. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
   a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
   b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
   c. Factory-installed and pressure-tested piping with isolation valves and accessories.
   d. Oil compatible with refrigerant and chiller components.
   e. Positive visual indication of oil level.
9. Vibration Control:
   a. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.
      1) Overspeed Test: 25 percent above design operating speed.
   b. Isolation: Mount individual compressors on vibration isolators.
10. Compressor Motors:
   a. Hermetically sealed and cooled by refrigerant suction gas.
   b. High-torque, induction type with inherent thermal-overload protection on each phase.
11. Compressor Motor Controllers:
   a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state, **as directed**.
   b. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition, or solid state, **as directed**.
   c. Variable Frequency Controller:
      1) Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
      2) Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
      3) Enclosure: Unit mounted, NEMA 250, Type 3R, **as directed**, with hinged full-front access door with lock and key.
      4) Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
      5) Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.
      6) Motor current at start shall not exceed the rated load amperes, providing no electrical inrush.
12. Refrigerant Circuits:
   a. Refrigerant: Type as indicated on Drawings.
      OR
      Refrigerant Type: R-22 **OR** R-134a **OR** R-407c **OR** HFC, **as directed**: Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   c. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction, **as directed**, and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core, **as directed**, filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
   d. Pressure Relief Device:
      1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
      2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
13. Evaporator:

a. Description: Shell-and-tube design.
   1) Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
   2) Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
c. Shell Material: Carbon steel.
d. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.
e. Fluid Nozzles: Terminated with mechanical-coupling **OR** flanged, **as directed**, end connections for connection to field piping.
f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
g. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
h. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.

14. Air-Cooled Condenser:
   a. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).
      1) Construct coil casing of galvanized **OR** stainless, **as directed**, steel.
      2) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.
      3) Coat coils with a baked-epoxy, corrosion-resistant coating after fabrication.
      4) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
   b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
   c. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
   d. Fan Guards: Steel safety guards with corrosion-resistant coating.

15. Electrical Power:
   a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint **OR** single-point, **as directed**, field-power connection to chiller.
   b. House in a unit-mounted, NEMA 250, Type 3R, **as directed**, enclosure with hinged access door with lock and key or padlock and key, **as directed**.
   c. Wiring shall be numbered and color-coded, **as directed**, to match wiring diagram.
   d. Install factory wiring outside of an enclosure in a raceway.
   e. Field-power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch **OR** NEMA AB 1, instantaneous-trip circuit breaker with lockable handle, **as directed**.
      1) Disconnect means shall be interlocked with door operation.
      2) Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
   f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
      1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
   g. Provide each motor with overcurrent protection.
   h. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
   i. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.

j. Provide power factor correction capacitors to correct power factor to 0.90 **OR** 0.95, **as directed**, at full load.

k. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
   1) Power unit-mounted controls where indicated.
   2) Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.

l. Control Relays: Auxiliary and adjustable time-delay relays.

m. For chiller electrical power supply, indicate the following:
   1) Current and phase to phase for all three phases.
   2) Voltage, phase to phase, and phase to neutral for all three phases.
   3) Three-phase real power (kilowatts).
   4) Three-phase reactive power (kilovolt amperes reactive).
   5) Power factor.
   6) Running log of total power versus time (kilowatt-hours).
   7) Fault log, with time and date of each.

16. Controls:

a. Standalone and microprocessor based.

b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure for remote mounting in the field, **as directed**.

c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
   1) Date and time.
   2) Operating or alarm status.
   3) Operating hours.
   4) Outdoor-air temperature if required for chilled-water reset.
   5) Temperature and pressure of operating set points.
   6) Entering and leaving temperatures of chilled water.
   7) Refrigerant pressures in evaporator and condenser.
   8) Saturation temperature in evaporator and condenser.
   9) No cooling load condition.
   10) Elapsed time meter (compressor run status).
   11) Pump status.
   12) Antirecycling timer status.
   13) Percent of maximum motor amperage.
   14) Current-limit set point.
   15) Number of compressor starts.

d. Control Functions:
   1) Manual or automatic startup and shutdown time schedule.
   2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
   3) Current limit and demand limit.
   4) External chiller emergency stop.
   5) Antirecycling timer.
   6) Automatic lead-lag switching.
   7) Variable evaporator flow.
   8) Thermal storage.

e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
   1) Low evaporator pressure or high condenser pressure.
   2) Low chilled-water temperature.
   3) Refrigerant high pressure.
   4) High or low oil pressure.
   5) High oil temperature.
   6) Loss of chilled-water flow.

7) Control device failure.

f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

i. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.

1) Hardwired Points:

a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours), **as directed**.

b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.

2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

17. Insulation:

a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

b. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.

c. Factory-applied insulation over cold surfaces of chiller components.

1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.

d. Apply protective coating to exposed surfaces of insulation to protect insulation from weather.

18. Accessories:

a. Factory-furnished, chilled-water flow switches for field installation.

b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.

c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.

D. Packaged Refrigerant Recovery Units

1. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.

E. Heat-Exchanger, Brush-Cleaning System

1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.

2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.

3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.

4. Components:

a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
b. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
c. Four-Way Valve:
   1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
   2) Configure valve with parallel flow connections to minimize field installation piping.
   3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
   4) Pipe connections shall be flanged.
   5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
   6) Hydrostatically test to 1.5 times the design working pressure.
   7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
   8) Provide valve with valve-mounted indicating/warning light, which shall light before valve begins rotation.
   9) Valve Actuator: Mount electric actuator to operate valve.
      OR
      Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
   10) Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.
d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
   1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
   2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
   3) Manual override of preset cleaning cycle.
   4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
   5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
   6) Flow switch bypass.
   7) Unloading signal to chiller.

F. Source Quality Control
1. Perform functional tests of chillers before shipping.
2. Factory run test each air-cooled chiller with water flowing through evaporator.
3. Factory performance test water-cooled chillers, before shipping, according to ARI 550/590.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
         OR
         Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
         OR
         At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
   b. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.

c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

4. Factory performance test air-cooled chillers, **as directed**, before shipping, according to ARI 550/590.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser air at design conditions.
         OR
         At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
   b. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
   c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
5. Factory sound test water-cooled chillers, **as directed**, before shipping, according to ARI 575 **OR** air-cooled chillers, before shipping, according to ARI 370, **as directed**.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Chiller operating at calculated worst-case sound condition.
         OR
         At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
   b. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
   c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
6. Factory test and inspect evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
7. For chillers located indoors, rate sound power level according to ARI 575.
8. For chillers located outdoors, rate sound power level according to ARI 370.

1.3 EXECUTION

A. Chiller Installation
   1. Install chillers on support structure indicated.
   2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
      a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
      b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
      c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      e. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Equipment Mounting: Install chiller using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.

4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Maintain manufacturer's recommended clearances for service and maintenance.
6. Charge chiller with refrigerant and fill with oil if not factory installed.
7. Install separate devices furnished by manufacturer and not factory installed.

B. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
3. Provide field electric power, as required, to each system control panel and electric actuated valve.
4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

C. Connections
1. Comply with requirements for piping specified in Division 15 Section(s) "Hydronic Piping" AND "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to chiller to allow service and maintenance.
3. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
4. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
5. Heat-Reclaim Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
7. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
   c. Verify that pumps are installed and functional.
   d. Verify that thermometers and gages are installed.
   e. Operate chiller for run-in period.
   f. Check bearing lubrication and oil levels.
   g. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
   h. Verify proper motor rotation.
   i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
   j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**.
   k. Verify and record performance of chiller protection devices.
   l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

END OF SECTION 15655a

SECTION 15661 - CONDENSING UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for condensing units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes air-cooled and water-cooled condensing units.

C. Submittals
1. Product Data: For each condensing unit, include rated capacities, operating characteristics, furnished specialties, and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Shop Drawings: Signed and sealed by a qualified professional engineer.
   a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
   b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
   c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that condensing units, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.
7. LEED Submittal:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. ASME Compliance: Fabricate and label water-cooled condensing units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Compressor failure.
      2) Condenser coil leak.

b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Substantial Completion.
c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Substantial Completion.
d. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Condensing Units, Air Cooled, 1 To 5 Tons (3.5 TO 17.6 kW)
1. Description: Factory assembled and tested, consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
2. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
a. Motor: Single **OR** Two, **as directed**, speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
b. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
c. Accumulator: Suction tube.
d. Refrigerant Charge: R-22 **OR** R-407C **OR** R-410A, **as directed**.
3. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.
4. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings, **as directed**.
5. Accessories:
a. Coastal Filter: Mesh screen to protect condenser coil from salt damage.
b. Crankcase heater.
c. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
d. Electronic programmable thermostat **OR** Low-voltage thermostat and subbase, **as directed**, to control condensing unit and evaporator fan.
e. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
f. Filter-dryer.
g. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
h. Liquid-line solenoid.
i. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
OR
Low Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
j. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
k. PE mounting base to provide a permanent foundation.
l. Precharged and insulated suction and liquid tubing.
m. Sound Hood: Wraps around sound attenuation cover for compressor.
n. Thermostatic expansion valve.
o. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
6. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

B. Condensing Units, Air Cooled, 6 To 120 Tons (21 TO 422 kW)
1. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.

2. Compressor: Hermetic or semihermetic compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
   a. Capacity Control: Cylinder unloading **OR** Hot-gas bypass, **as directed**.
   b. Refrigerant Charge: R-22 **OR** R-407C **OR** R-410A **OR** HFC-134a, **as directed**.
3. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
4. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
   a. Permanently lubricated ball-bearing motors.
   b. Separate motor for each fan.
   c. Dynamically and statically balanced fan assemblies.
5. Operating and safety controls include the following:
   a. Manual-reset, high-pressure cutout switches.
   b. Automatic-reset, low-pressure cutout switches.
   c. Low oil pressure cutout switch.
   d. Compressor-winding thermostat cutout switch.
   e. Three-leg, compressor-overload protection.
   f. Control transformer.
   g. Magnetic contactors for compressor and condenser fan motors.
   h. Timer to prevent excessive compressor cycling.
6. Accessories:
   a. Electronic programmable thermostat **OR** Low-voltage thermostat and subbase, **as directed**, to control condensing unit and evaporator fan.
   b. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
      OR
      Low Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
   c. Gage Panel: Package with refrigerant circuit suction and discharge gages.
   d. Hot-gas bypass kit.
   e. Part-winding-start timing relay, circuit breakers, and contactors.
7. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
   a. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
   b. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
   c. Gasketed control panel door.
   d. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
   e. Condenser coil hail guard **OR** grille, **as directed**, to protect coil from physical damage.

C. Condensing Units, Water Cooled
1. Description: Factory assembled and tested, water cooled; consisting of compressors, water-cooled condensers, bases, and unit controls.
2. Compressor: Hermetic or serviceable hermetic type; with oil pump, operating oil charge, and suction and discharge shutoff valves. Factory mounted on base using spring isolators. Include the following:
   a. Thermally protected compressor motor.
   b. Crankcase heater.
   c. Capacity control using cylinder unloading, suction pressure controlled and discharge pressure operated, designed for unloaded start.
   d. Refrigerant Charge: R-22 **OR** R-407C **OR** R-410A **OR** HFC-134a, **as directed**.

3. Condenser: Single-pass, tube-in-tube coaxial type; with seamless, integral-finned, copper tube and steel outer shell with water-regulating valve.
   OR
   Condenser: Multipass, shell-and-tube type; with replaceable, seamless, integral-finned copper tubes; positive-liquid subcooling circuit; pressure relief device; liquid-level test cock; purge connection; liquid-line shutoff valve; and angle valve for connection of water-regulating valve.
   a. Unit Construction: ASME stamped, **as directed**, for refrigerant-side working pressure of 385 psig (2650 kPa) and water-side working pressure of 250 psig (1720 kPa).
4. Accessories include the following:
   a. Discharge-line muffler.
   b. Gage panel containing gages for suction, discharge, and oil pressure.
   c. Electric solenoid cylinder unloaders.
   d. Pump-down relay package.
   e. Crankcase cover plates with equalizer connections.
5. Controls: Factory-mounted and -wired panel with the following:
   a. Timer to prevent short cycling.
   b. High- and low-refrigerant-pressure safety controls.
   c. Power- and control-circuit terminal blocks.
   d. Compressor motor starter.
   e. Control-circuit on-off switch.
   f. Control-circuit fuse.

D. Motors
1. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 15.

E. Source Quality Control
1. Verification of Performance: Rate condensing units according to ARI 210/240, ARI 340/360, or ARI 365.
   a. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
2. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

1.3 EXECUTION

A. Installation
1. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
2. Install condensing units on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 02.
3. Concrete Bases:
   a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of the base.
   b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

d. Install anchor bolts to elevations required for proper attachment to supported equipment.
e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

4. Install roof-mounting units on equipment supports specified in Division 05.
5. Vibration Isolation: Mount condensing units on rubber pads with a minimum deflection of 1/4 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   OR
   Vibration Isolation: Mount condensing units on restrained spring isolators with a minimum deflection specified by the Owner. Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Maintain manufacturer's recommended clearances for service and maintenance.
7. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.
4. Connect refrigerant piping to air-cooled condensing units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Division 15 Section "Refrigerant Piping".
5. Connect refrigerant and condenser-water piping to water-cooled condensing units. Maintain clear tube removal space. Refrigerant piping and specialties are specified in Division 15 Section "Refrigerant Piping" and condenser-water piping and specialties are specified in Division 15 Section(s) "Domestic Water Piping" OR "Hydronic Piping", **as directed**.

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Perform electrical test and visual and mechanical inspection.
   b. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   e. Verify proper airflow over coils.
2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
3. Remove and replace malfunctioning condensing units and retest as specified above.

D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Inspect for physical damage to unit casing.
   b. Verify that access doors move freely and are weathertight.
   c. Clean units and inspect for construction debris.
   d. Verify that all bolts and screws are tight.
   e. Adjust vibration isolation and flexible connections.
   f. Verify that controls are connected and operational.
2. Lubricate bearings on fans.
3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
4. Adjust fan belts to proper alignment and tension.

5. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
6. Measure and record airflow over coils.
7. Verify proper operation of condenser capacity control device.
8. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
9. After startup and performance test, lubricate bearings and adjust belt tension, **as directed**.

E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.

END OF SECTION 15661

SECTION 15661a - AIR-COOLED CONDENSERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for air-cooled condensers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged, air-cooled condensers for outdoor and indoor installation.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer.
   a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
   b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
   c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that air-cooled condensers, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. LEED Submittal:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.2 PRODUCTS

A. Manufactured Units
1. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.
2. Condenser Coil: Seamless copper-tube, finned coil; factory tested at 425 psig (2930 kPa).
   a. Coil Fin: Aluminum **OR** Copper, **as directed**.
   b. Coil Coating: **As directed**.
   c. Circuit: To match compressors with liquid subcooling coil, **as directed**.
   d. Refrigerant Accessories, **as directed**: Provide receiver, pressure control, and solenoid valve for each circuit.

3. Condenser Fans and Drives: Propeller fans with aluminum or galvanized-steel **OR** galvanized-steel **OR** stainless-steel, **as directed**, fan blades, for vertical **OR** horizontal, **as directed**, air discharge; directly driven with permanently lubricated ballbearing motors with integral current- and thermal-overload protection.
   OR
   Condenser Fans and Drives: Forward-curved centrifugal fans for vertical **OR** horizontal, **as directed**, air discharge.
   a. Fan on steel shaft with self-aligning ball bearings.
   b. V-belt drive with minimum of two belts; variable pitch drive pulley.
   c. Motor mounted on adjustable slide base.
4. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; 115-V control transformer, if required; magnetic contactors for condenser fan motors and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
5. Unit Casings: Galvanized or zinc-coated steel treated and finished with manufacturer's standard paint coating **OR** Stainless steel, **as directed**, designed for outdoor installation with weather protection for components and controls **OR** indoor installation, **as directed**, and with the following:
   a. Removable panels for access to controls, condenser fans, motors, and drives.
   b. Plated-steel **OR** Stainless-steel, **as directed**, fan guards.
   c. Lifting eyes.
   d. Removable legs.
   e. 1-inch- (25-mm-) thick inlet filter.

B. Motors
1. General requirements for motors are specified in Division 14 Section "Chutes".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 15.

C. Source Quality Control
1. Verification of Performance: Rate air-cooled condensers according to ARI 460.
2. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

1.3 EXECUTION

A. Installation
1. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
2. Install air-cooled condensers on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 02.
3. Concrete Bases:
   a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of the base.
   b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
   e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Install roof-mounting units on equipment supports specified in Division 05.

5. Vibration Isolation: Mount air-cooled condensers on rubber pads with a minimum deflection of 1/4 inch (6.35 mm). Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   OR
   Vibration Isolation: Mount air-cooled condensers on restrained spring isolators with a minimum deflection of <**Insert measurement**>. Vibration isolation devices and installation requirements are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Secure vibration and seismic controls, and suspended units to structure.
   OR
   Support suspended units from structure using threaded steel rods.
7. Maintain manufacturer's recommended clearances for service and maintenance.
8. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Refrigerant Piping: Connect piping to unit with pressure relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line. Refrigerant piping and specialties are specified in Division 15 Section "Refrigerant Piping".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Perform electrical test and visual and mechanical inspection.
   b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   e. Verify proper airflow over coils.
2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
3. Remove and replace malfunctioning air-cooled condensers and retest as specified above.

D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Inspect for physical damage to unit casing.
   b. Verify that access doors move freely and are weathertight.
   c. Clean units and inspect for construction debris.
   d. Verify that all bolts and screws are tight.
   e. Adjust vibration isolation and flexible connections.
   f. Verify that controls are connected and operational.
2. Lubricate bearings on fans.
3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
4. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
5. Measure and record airflow over coils.
6. Verify proper operation of capacity control device.

7. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
8. After startup and performance test, lubricate bearings.

E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air-cooled condensers.

END OF SECTION 15661a

SECTION 15661b - SPLIT-SYSTEM AIR-CONDITIONING UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for split-system air-conditioning units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

C. Submittals
1. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. Concealed Evaporator-Fan Components
1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
   a. Insulation: Faced, glass-fiber duct liner.
   b. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2004, **as directed**.
   c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
3. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.
   OR
   Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
5. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
6. Disposable Filters: 1 inch (25 mm) thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
7. Wiring Terminations: Connect motor to chassis wiring with plug connection.

B. Floor-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner.
   a. Discharge Grille: Steel with surface-mounted frame **OR** Welded steel bars forming a linear grille and welded into supporting panel, **as directed**.
   b. Insulation: Faced, glass-fiber, duct liner.
   c. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2004, **as directed**.
   d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
3. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a 2-position control valve.
   OR
   Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal, with power-induced outside air, **as directed**.
5. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.

C. Wall-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner, and discharge drain pans with drain connection.
   a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
   b. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2004.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal fan.
5. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.

D. Ceiling-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner, and discharge drain pans with drain connection.
   a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
   b. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2004.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal fan, with power-induced outside air, **as directed**, and integral condensate pump.
5. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.

E. Air-Cooled, Compressor-Condenser Components
1. Casing: Steel, finished with baked enamel in color selected by the Owner, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   a. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
4. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.
5. Fan: Aluminum-propeller type, directly connected to motor.
6. Motor: Permanently lubricated, with integral thermal-overload protection.
7. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
8. Mounting Base: Polyethylene.
9. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

F. Water-Cooled, Compressor-Condenser Components

1. Casing: Steel, with baked-enamel finish in color selected by the Owner, removable panels for access to controls, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   a. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
   b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
   c. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
3. Heat Pump Components: Reversing valve.
4. Heat Exchanger: Copper tubes in copper tube or in steel shell, with water-temperature-actuated, water-regulating valve.
5. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

G. Accessories
1. Control equipment and sequence of operation are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
2. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
3. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
   a. Compressor time delay.
   b. 24-hour time control of system stop and start.
   c. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
   d. Fan-speed selection, including auto setting.
4. Automatic-reset timer to prevent rapid cycling of compressor.
5. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
   a. Minimum Insulation Thickness: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.

1.3 EXECUTION

A. Installation
1. Install units level and plumb.
2. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
3. Install ground-mounting, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete". Coordinate anchor installation with concrete base.
   OR
   Install ground-mounting, compressor-condenser components on polyethylene mounting base.
4. Install roof-mounting compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories". Anchor units to supports with removable, cadmium-plated fasteners.
5. Install seismic restraints.
6. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch (25 mm). Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
7. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

B. Connections
   1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
      a. Water Coil Connections: Comply with requirements in Division 15 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
      b. Remote Water-Cooled Condenser Connections: Comply with requirements in Division 15 Section "Hydronic Piping". Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
      c. Steam Coil Connections: Comply with requirements in Division 15 Section "Steam And Condensate Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.
   2. Install piping adjacent to unit to allow service and maintenance.
   3. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories".
   4. Ground equipment according to Division 16 Section "Grounding And Bonding".
   5. Electrical Connections: Comply with requirements in Division 15 for power wiring, switches, and motor controls.

C. Field Quality Control
   1. Perform the following field tests and inspections and prepare test reports:
      a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
      b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
      c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   2. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service
   1. Engage a factory-authorized service representative to perform startup service.
      a. Complete installation and startup checks according to manufacturer's written instructions.

E. Demonstration
   1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 15661b

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Task	Specification	Specification Description
15662	15661	Condensing Units

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SECTION 15670 - INDIRECT-FIRED ABSORPTION WATER CHILLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for indirect-fired absorption water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Packaged, water-cooled, single-effect and double-effect absorption chillers.
b. Heat-exchanger, brush-cleaning system.

C. Definitions
1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 560 and referenced to ARI standard rating conditions.
4. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 560 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements
1. Seismic Performance: Indirect-fired absorption chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) **OR** 55 deg F (13 deg C) **OR** 40 deg F (4.4 deg C), **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 65 deg F (18 deg C) **OR** 60 deg F (16 deg C) **OR** 55 deg F (13 deg C), **as directed**.
c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 560, **as directed**:
a. Allowable Capacity Tolerance: Zero percent.
b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories.
2. LEED Submittals:
a. Product Data for LEED-NC Prerequisite EA 2: Documentation indicating that units comply with ASHRAE 90.1-2004.

b. Product Data for LEED-NC Prerequisite EA 3: Documentation indicating that refrigerants comply.
c. Product Data for LEED-NC Credit EA 4: Documentation indicating that equipment and refrigerants comply.

3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance
1. ARI Rating: Rate chiller performance according to requirements in ARI 560.
2. ASHRAE Compliance:
   a. ASHRAE 15 for safety code for mechanical refrigeration.
   b. ASHRAE/IESNA 90.1-2004.
3. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
4. Comply with NFPA 70.
5. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.

G. Delivery, Storage, And Handling
1. Ship chillers factory charged with nitrogen.
2. Ship absorbent and refrigerant in chillers or in containers separate from chillers.
   OR
   Ship absorbent and refrigerant, **as directed**, in containers separate from chillers.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
   a. Extended warranties include, but are not limited to, the following:
      1) Complete chiller.
         OR
         Pumps and motors **OR** Purge unit, **as directed**.
         OR
         Absorbent **OR** Absorbent and refrigerant, **as directed**, only.
      2) Parts only **OR** Parts and labor, **as directed**.
      3) Loss of absorbent and refrigerant for any reason.
2. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Unit

1. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
   a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. Absorbent and Refrigerant:
   a. Absorbent: Lithium bromide solution with corrosion inhibitor.
   b. Refrigerant: Deionized or distilled, **as directed**, water.
   c. Performance Enhancer: Heat and mass transfer enhancer to improve performance.
3. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

B. Pumps
1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating tapered carbon bearings.
2. Pump motor assembly shall be designed to operate for not less than 25,000 **OR** 50,000, **as directed**, hours between inspections.
3. Pump motors cooled, and bearings lubricated, either by fluid being pumped or by a filtered supply of liquid refrigerant.
4. Pump suction and discharge equipped with isolation valves.
5. Separate and dedicated pumps for absorbent solution and refrigerant.
   a. Absorbent solution and refrigerant flow-control method shall be manufacturer's choice to comply with operating requirements indicated.
6. Purge System: Unit mounted and factory wired, equipped with controls and a pump to automatically remove noncondensable vapors.
   a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
      1) Enclosure: Open dripproof **OR** Totally enclosed, **as directed**.

C. Heat-Exchanger Shells
1. Configuration for Single-Effect Chillers: Two shells; one shell consists of the absorber/evaporator and the other shell consists of the condenser/generator.
2. Configuration for Double-Effect Chillers: Two shells; one shell consists of the absorber/evaporator, low-stage generator/condenser and the other shell consists of the high-stage generator.
3. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
4. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
5. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
6. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
7. Generator/Condenser Shell Pressure Relief Device: Manufacturers standard rupture disk complying with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. Absorber
1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
2. Tubes:

a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
d. External Finish: Manufacturer's standard.
e. Internal Finish: Enhanced **OR** Smooth, **as directed**.

3. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard **OR** Marine, **as directed**, type for water box with piping connections.
      1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
      2) Hinged **OR** davited, **as directed**, water boxes.
         OR
         Hinged **OR** davited, **as directed**, marine water-box covers.

      OR

      Standard type for water box without piping connections.
      1) Water boxes shall have lifting lugs or eyebolts.
      2) Hinged **OR** davited, **as directed**, water boxes.
         OR
         Hinged **OR** davited, **as directed**, marine water-box covers.
   c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   d. Thermistor or RTD temperature sensor factory installed in each nozzle.
   e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm) **OR** 3/4- or 1-inch (19- or 25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
   a. Electrolytic corrosion-inhibitor anode.
   b. Coat wetted surfaces with a corrosion-resistant finish.
      OR
      Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
5. Absorber/Condenser Crossover Piping: Factory furnished **OR** installed, **as directed**, piping connecting fluid connection of absorber discharge to condenser inlet.

E. Evaporator
1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
2. Refrigerant Holding Pan: Steel **OR** Stainless steel, **as directed**.
3. Tubes:
   a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
   b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
   c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
4. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard **OR** Marine, **as directed**, type for water box with piping connections.

1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.

OR
Standard type for water box without piping connections.
1) Water boxes shall have lifting lugs or eyebolts.
2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.

c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
d. Thermistor or RTD temperature sensor factory installed in each nozzle.
e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm) **OR** 3/4- or 1-inch (19- or 25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

F. Condenser
1. Refrigerant Holding Pan: Steel **OR** Stainless steel, **as directed**.
2. Tubes:
a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
d. External Finish: Manufacturer's standard.
e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
b. Standard **OR** Marine, **as directed**, type for water box with piping connections.
1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.

OR
Standard type for water box without piping connections.
1) Water boxes shall have lifting lugs or eyebolts.
2) Hinged **OR** davited, **as directed**, water boxes.
OR
Hinged **OR** davited, **as directed**, marine water-box covers.

c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
d. Thermistor or RTD temperature sensor factory installed in each nozzle.
e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
a. Electrolytic corrosion-inhibitor anode.
b. Coat wetted surfaces with a corrosion-resistant finish.
OR
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

G. Generator For Single-Effect Chillers
1. Tubes:
   a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
   b. Material: 90/10 copper-nickel alloy **OR** Stainless steel **OR** Titanium**,** as directed.
   c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.035 inch (0.9 mm), **as directed**.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Smooth **OR** Enhanced, **as directed**
2. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard type water box.
   c. Water boxes shall have lifting lugs or eyebolts.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
   a. Electrolytic corrosion-inhibitor anode.
   b. Coat wetted surfaces with a corrosion-resistant finish.
      OR
      Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

H. First-Stage Generator For Double-Effect Chillers
1. Tubes:
   a. Replaceable, straight, or U tubes expanded into tube sheets.
   b. Material: Manufacturer's standard **OR** 70/30 copper-nickel alloy **OR** Type 409 stainless steel **OR** Titanium, **as directed**.
   c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Smooth **OR** Enhanced, **as directed**.
2. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard type water box.
   c. Water boxes shall have lifting lugs or eyebolts.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
   a. Electrolytic corrosion-inhibitor anode.
   b. Coat wetted surfaces with a corrosion-resistant finish.
      OR
      Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

I. Second-Stage Generator For Double-Effect Chillers
1. Tubes:

a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
d. External Finish: Manufacturer's standard.
e. Internal Finish: Smooth **OR** Enhanced, **as directed**.

2. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard type water box.
   c. Water boxes shall have lifting lugs or eyebolts.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
   a. Electrolytic corrosion-inhibitor anode.
   b. Coat wetted surfaces with a corrosion-resistant finish.
      OR
      Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

J. Solution Heat Exchanger
1. Description: Shell-and-tube or brazed-plate heat exchanger; integral part of chiller to increase cycle efficiency by preheating the weak solution on its way to the generator while precooling the strong solution returning from the generator.

K. Steam Condensate Drain Cooler
1. Description: Shell-and-tube heat exchanger constructed of carbon-steel shell and copper-nickel-alloy or stainless-steel tubes.

L. Factory-Applied Insulation
1. Factory-Applied Insulation on Cold Surfaces:
   a. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tube and Type II for sheet materials.
      1) Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
   b. Adhesive: As recommended by insulation manufacturer.
   c. Factory apply insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets; evaporator water boxes including nozzles; refrigerant pump; cold surfaces of motor; and cold piping.
      1) Apply adhesive to 100 percent of insulation contact surface.
      2) Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
      3) Seal seams and joints to provide a vapor barrier.
      4) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
2. Factory-Applied Insulation on Hot Surfaces:
   a. Mineral-fiber board, pipe or tank insulation complying with one of following:
      1) ASTM C 547, Type I or Type II, Grade A.
      2) ASTM C 612, Type IB.
      3) ASTM C 1393, Type II or Type IIIA, Category 2.
      4) Thickness: 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**.

b. Adhesive: As recommended by insulation manufacturer.
c. Factory apply materials over all hot surfaces to provide smooth, straight, and even surfaces; free of voids.
   1) Apply adhesive to insulation contact surface as recommended by insulation manufacturer.
   2) Install insulation anchor pins and washers if required by insulation manufacturer to secure insulation to surfaces to be insulated.
   3) Completely encapsulate insulation with metal jacket, leaving no exposed insulation. Provide removable jacket on components requiring access for service and inspection.
   4) Paint exposed surfaces of metal jacket to match other painted parts unless jacket material is aluminum or stainless steel.

M. Electrical
1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
   a. Branch power circuit to each motor, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
      1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
   b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
   c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.

N. Controls
1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x, **as directed**, hinged or lockable.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
   a. Date and time.
   b. Operating or alarm status.
   c. Operating hours.
   d. Outdoor-air temperature if required for chilled-water reset.
   e. Temperature and pressure of operating set points.
   f. Entering and leaving temperatures of chilled and condenser water.
   g. Refrigerant temperature.
   h. Solution concentration and temperature.
   i. Indication of solution and purge-pump operation.
   j. Generator shell pressure.
   k. Number of starts.
   l. Number of purge cycles.
   m. Hot-water valve actuator potentiometer position (percentage).
   n. Entering and leaving hot-water temperatures.

o. Steam demand limit.
p. Inlet steam pressure and temperature.
q. Steam valve actuator potentiometer position (percentage).
r. First-stage generator pressure and temperature.

4. Control Functions:
   a. Manual or automatic startup and shutdown time schedule.
   b. Automatic cycle to prevent crystallization.
   c. Entering and leaving chilled-water temperatures and control set points. Chilled-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
   d. Condenser-fluid temperature.
   e. Cooling provided and heating energy used within programmable time periods, minimum monthly.
5. Capacity Control: Automatically controls input flow rate of heat source to maintain chilled-water temperature set point for cooling loads ranging from 10 to 100 percent.
6. Control Valve Package: Factory-furnished, for field installation, **OR** Factory-installed, **as directed**, control valve package suitable for energy source indicated.
   a. Body: Cast-iron, carbon-steel, or stainless-steel body with flanged connections.
   b. Type: Manufacturer's choice **OR** V-notch ball **OR** Butterfly **OR** Globe style with cage-guide plug, **as directed**, constructed of stainless steel.
   c. Rating: Pressure and temperature rating to match heat exchanger.
   d. Shutoff: Capable of bubble-tight shutoff against maximum system pressure.
   e. Size: Determined by chiller manufacturer.
   f. Modulation: Two-way **OR** Three-way, **as directed**.
   g. Turndown: As required to achieve stable control through the indicated operating range.
   h. Actuator: Electric powered from chiller control panel and installed on valve.
7. Safety Shutdowns:
   a. Crystallization.
   b. Low refrigerant temperature.
   c. Loss of chilled- or condenser-water flow.
   d. Low leaving chilled-water temperature, 2 deg F (1 deg C) below set point, **as directed**.
   e. First-stage generator low-solution level.
   f. First-stage generator high temperature or pressure.
   g. Power failure.
   h. Solution pump overloads.
   i. External auxiliary safety shutdown.
   j. High solution concentration.
   k. Incomplete dilution cycle.
   l. High entering-water temperature.
   m. High inlet steam pressure and temperature.
8. Warning Conditions: Control panel shall close warning contacts and generate a message when one of the following operating conditions is detected:
   a. Low refrigerant temperature.
   b. High generator temperature or pressure.
   c. High entering generator-water temperature (single-stage generator only).
   d. High or low entering condenser-water temperature.
   e. Solution temperature sensor failure.
   f. Low chilled-water flow.
9. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
10. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
11. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

12. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
13. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    a. Hardwired Points:
        1) Monitoring: On-off status, common trouble alarm.
        2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** generator heat source capacity limiting, **as directed**.
    b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

O. Finish
1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
    a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
    b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
    c. Paint surfaces that are to be insulated before applying the insulation.
    d. Paint installed insulation to match adjacent uninsulated surfaces.
    e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner.
2. Provide Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

P. Accessories
1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
2. Flow Switches:
    a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
    b. Paddle Flow Switches:
        1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
        2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
        3) Pressure rating equal to pressure rating of heat exchanger.
        4) Construct body and wetted parts of Type 316 stainless steel.
        5) House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
        6) Vane length to suit installation.

        OR

        Pressure Differential Switches:
        1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
        2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
        3) Set Point: Screw type, field adjustable.
        4) Electrical Connections: Internally mounted screw-type terminal blocks.
        5) Switch Enclosure: NEMA 250, Type 4.
        6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
3. Vibration Isolation:
    a. Chiller manufacturer shall furnish neoprene-pad vibration isolation for each chiller.

1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
2) Fabricate pads from 40- to 50-durometer neoprene.
3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

4. Lithium Bromide Filter, **as directed**:
   a. Factory install a filter, isolation valves, and associated piping.
   b. Filter shall consist of a stainless-steel body, with removable and cleanable 150-micron, stainless-steel element.
   c. Isolation valves shall provide isolation for filter servicing without disturbing operation of chiller.

Q. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
4. Components:
   a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
   b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
   c. Four-Way Valve:
      1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
      2) Configure valve with parallel flow connections to minimize field installation piping.
      3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
      4) Pipe connections shall be flanged.
      5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
      6) Hydrostatically test to 1.5 times the design working pressure.
      7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
      8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
      9) Valve Actuator: Mount electric actuator to operate valve.
         OR
         Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
      10) Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.
   d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
      1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
      2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
      3) Manual override of preset cleaning cycle.
      4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.

5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
6) Flow-switch bypass.
7) Unloading signal to chiller.

R. Source Quality Control
1. Perform functional tests **OR** run tests, **as directed**, of chillers before shipping.
2. Factory test and inspect absorber, generator, evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Vacuum and pressure test shells for leaks.
3. Rate sound power level according to ARI 575.
4. Factory performance test chillers, before shipping, according to ARI 560, **as directed**.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
      OR
      Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
      OR
      At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
5. Factory sound test chillers, before shipping, according to ARI 575, **as directed**.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Chiller operating at calculated worst-case sound condition.
      3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
6. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
7. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

1.3 EXECUTION

A. Chiller Installation
1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.

4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install chillers with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
7. Maintain manufacturer's recommended clearances for service and maintenance.
8. Charge chiller with absorbent and refrigerant if not factory charged.
9. Install separate devices furnished by manufacturer and not factory installed.
10. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Division 15 Section "Hvac Insulation".

B. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
3. Provide field electric power, as required, to each system control panel and electric actuated valve.
4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

C. Connections
1. Comply with requirements in Division 15 Section "Hydronic Piping" for hydronic piping. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements in Division 15 Section "Steam And Condensate Piping" for steam and condensate piping. Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to chiller to allow service and maintenance.
4. Generator Steam Piping Connections:
   a. Connect steam piping with trapped drip leg, gate valve, strainer, control valve, and pressure gage. Install pressure reducing valve and safety relief valve upstream from steam-control valve to protect control valve from excessive steam pressure. Make connections to chiller with a flange **OR** union, **as directed**.
   b. Connect steam condensate piping with vacuum breaker, trapped drip leg, gate valve, strainer, float and thermostatic trap(s), condensate cooler, **as directed**, condensate receiver, **as directed**, condensate receiver and pump, **as directed**, and check valve. Make connections to chiller with a flange **OR** union, **as directed**.
5. Generator Hot-Water Connections: Connect to generator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, control valve, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to generator outlet with shutoff valve, check valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with

shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.

6. Evaporator-Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
7. Absorber/Condenser-Fluid Connections: Connect to inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
   a. If not factory furnished or installed, provide pipe connecting fluid connection of absorber discharge and condenser inlet.
8. Refrigerant Pressure Relief Device Connections: Extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
9. Extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15.
10. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Operate chiller for run-in period.
   c. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
   d. Verify that pumps are installed and functional.
   e. Verify that thermometers and gages are installed.
   f. Operate chiller for run-in period.
   g. Verify that refrigerant pressure relief device is vented outside.
   h. Verify proper motor rotation.
   i. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
   j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
   k. Verify and record performance of chiller protection devices.
   l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chillers.

END OF SECTION 15670

SECTION 15671 - SCROLL WATER CHILLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for scroll water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Packaged, water-cooled, electric-motor-driven, scroll water chillers.
b. Packaged, air-cooled, electric-motor-driven, scroll water chillers.
c. Packaged refrigerant recovery units.

C. Definitions
1. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
2. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
3. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
4. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
5. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements
1. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Certificates: For certification required in "Quality Assurance" Article.
4. Seismic Qualification Certificates: For water chillers, accessories, and components from manufacturers.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Startup service reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

F. Quality Assurance
1. ARI Certification: Certify chiller according to ARI 590 certification program.
2. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
3. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
4. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

G. Delivery, Storage, And Handling
1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
2. Package water chiller for export shipping.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. Packaged Water-Cooled Water Chillers
1. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
2. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
3. Compressors:
   a. Description: Positive-displacement direct drive with hermetically sealed casing.
   b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
   c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
   d. Capacity Control: On-off compressor cycling, plus hot-gas bypass, **as directed**.
   e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
   f. Vibration Isolation: Mount individual compressors on vibration isolators.
   g. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
4. Compressor Motors:
   a. Hermetically sealed and cooled by refrigerant suction gas.
   b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
5. Compressor Motor Controllers:
   a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
6. Refrigeration:
   a. Refrigerant: R-22. Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   c. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

7. Evaporator:
   a. Brazed-plate or shell-and-tube design, as indicated.
   b. Shell and Tube:
      1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
      2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
      3) Shell Material: Carbon steel.
      4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
      5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
      6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
   c. Brazed Plate:
      1) Direct-expansion, single-pass, brazed-plate design.
      2) Type 316 stainless-steel construction.
      3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
      4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
8. Condenser:
   a. Shell and tube or without integral condenser; as indicated.
   b. Shell and Tube:
      1) Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
      2) Provides positive subcooling of liquid refrigerant.
      3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
      4) Shell Material: Carbon steel.
      5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
      6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
      7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
   c. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 15 Section "Air-cooled Condensers".
9. Electrical Power:
   a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
   b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
   c. Wiring shall be numbered and color-coded to match wiring diagram.
   d. Install factory wiring outside of an enclosure in a raceway.
   e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
   f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
      1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

2) NEMA KS 1, heavy-duty, nonfusible switch.
3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

g. Provide each motor with overcurrent protection.

h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

j. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

k. Control Relays: Auxiliary and adjustable time-delay relays.

l. Indicate the following for water chiller electrical power supply:
1) Current, phase to phase, for all three phases.
2) Voltage, phase to phase and phase to neutral for all three phases.
3) Three-phase real power (kilowatts).
4) Three-phase reactive power (kilovolt amperes reactive).
5) Power factor.
6) Running log of total power versus time (kilowatt hours).
7) Fault log, with time and date of each.

10. Controls:

a. Stand-alone, microprocessor based.

b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
1) Date and time.
2) Operating or alarm status.
3) Operating hours.
4) Outside-air temperature if required for chilled-water reset.
5) Temperature and pressure of operating set points.
6) Entering and leaving temperatures of chilled water.
7) Entering and leaving temperatures of condenser water.
8) Refrigerant pressures in evaporator and condenser.
9) Saturation temperature in evaporator and condenser.
10) No cooling load condition.
11) Elapsed time meter (compressor run status).
12) Pump status.
13) Antirecycling timer status.
14) Percent of maximum motor amperage.
15) Current-limit set point.
16) Number of compressor starts.

d. Control Functions:
1) Manual or automatic startup and shutdown time schedule.
2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
3) Current limit and demand limit.
4) Condenser-water temperature.
5) External water chiller emergency stop.
6) Antirecycling timer.
7) Automatic lead-lag switching.

e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1) Low evaporator pressure or high condenser pressure.
2) Low chilled-water temperature.
3) Refrigerant high pressure.

4) High or low oil pressure.
5) High oil temperature.
6) Loss of chilled-water flow.
7) Loss of condenser-water flow.
8) Control device failure.

f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
1) Hardwired Points:
a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

11. Insulation:
a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
b. Thickness: 3/4 inch (19 mm).
c. Factory-applied insulation over cold surfaces of water chiller components.
1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
d. Apply protective coating to exposed surfaces of insulation.

12. Accessories:
a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.

B. Packaged Air-Cooled Water Chillers
1. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
2. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
3. Cabinet:
a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
c. Casing: Galvanized steel.
d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
e. Sound-reduction package consisting of the following:
1) Acoustic enclosure around compressors.
2) Reduced-speed fans with acoustic treatment.
3) Designed to reduce sound level without affecting performance.
f. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.
4. Compressors:

a. Description: Positive-displacement direct drive with hermetically sealed casing.
b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
d. Capacity Control: On-off compressor cycling, plus hot-gas bypass, **as directed**.
e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
f. Vibration Isolation: Mount individual compressors on vibration isolators.

5. Compressor Motors:
   a. Hermetically sealed and cooled by refrigerant suction gas.
   b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
6. Compressor Motor Controllers:
   a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
7. Refrigeration:
   a. Refrigerant: R-22 **OR** R-407c **OR** R-410a, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   c. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
   d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
8. Evaporator:
   a. Brazed-plate or shell-and-tube design, as indicated.
   b. Shell and Tube:
      1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
      2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
      3) Shell Material: Carbon steel.
      4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
      5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
      6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
   c. Brazed Plate:
      1) Direct-expansion, single-pass, brazed-plate design.
      2) Type 316 stainless-steel construction.
      3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
      4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
   d. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
   e. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
9. Air-Cooled Condenser:
   a. Plate-fin coil with integral subcooling on each circuit, rated at 450 psig (3103 kPa).
      1) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.

2) Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
3) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.

c. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.

d. Fan Guards: Steel safety guards with corrosion-resistant coating.

10. Electrical Power:

a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.

b. House in a unit-mounted, NEMA 250, Type 3R, **as directed**, enclosure with hinged access door with lock and key or padlock and key.

c. Wiring shall be numbered and color-coded to match wiring diagram.

d. Install factory wiring outside of an enclosure in a raceway.

e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.

f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:

1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
2) NEMA KS 1, heavy-duty, nonfusible switch.
3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

g. Provide each motor with overcurrent protection.

h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.

i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.

j. Provide power factor correction capacitors to correct power factor to 0.90 **OR** 0.95, **as directed**, at full load.

k. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.

1) Power unit-mounted controls where indicated.
2) Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.

l. Control Relays: Auxiliary and adjustable time-delay relays.

m. Indicate the following for water chiller electrical power supply:

1) Current, phase to phase, for all three phases.
2) Voltage, phase to phase and phase to neutral for all three phases.
3) Three-phase real power (kilowatts).
4) Three-phase reactive power (kilovolt amperes reactive).
5) Power factor.
6) Running log of total power versus time (kilowatt hours).
7) Fault log, with time and date of each.

11. Controls:

a. Stand-alone, microprocessor based.

b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:

1) Date and time.
2) Operating or alarm status.
3) Operating hours.
4) Outside-air temperature if required for chilled-water reset.
5) Temperature and pressure of operating set points.
6) Entering and leaving temperatures of chilled water.

7) Refrigerant pressures in evaporator and condenser.
8) Saturation temperature in evaporator and condenser.
9) No cooling load condition.
10) Elapsed time meter (compressor run status).
11) Pump status.
12) Antirecycling timer status.
13) Percent of maximum motor amperage.
14) Current-limit set point.
15) Number of compressor starts.

d. Control Functions:
1) Manual or automatic startup and shutdown time schedule.
2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
3) Current limit and demand limit.
4) External water chiller emergency stop.
5) Antirecycling timer.
6) Automatic lead-lag switching.

e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1) Low evaporator pressure or high condenser pressure.
2) Low chilled-water temperature.
3) Refrigerant high pressure.
4) High or low oil pressure.
5) High oil temperature.
6) Loss of chilled-water flow.
7) Control device failure.

f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
1) Hardwired Points:
a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

12. Insulation:
a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
b. Thickness: 3/4 inch (19 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
c. Factory-applied insulation over cold surfaces of water chiller components.
1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
d. Apply protective coating to exposed surfaces of insulation.

13. Accessories:
a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.

C. Packaged Refrigerant Recovery Units
   1. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.

D. Source Quality Control
   1. Perform functional test of water chillers before shipping.
   2. Factory performance test water chillers, **as directed**, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
      a. Allow Owner access to place where water chillers are being tested. Notify the Owner 14 days in advance of testing.
   3. Factory test and inspect evaporator and water-cooled condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
   4. For water chillers located indoors, rate sound power level according to ARI 575 procedure.
   5. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

1.3 EXECUTION

A. Water Chiller Installation
   1. Install water chillers on support structure indicated.
   2. Equipment Mounting: Install water chiller on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
      a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
      b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
      c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      e. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3. Equipment Mounting: Install water chiller using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
      a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
   4. Equipment Mounting: Install water chiller on vibration isolation inertia bases. Comply with requirements specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   5. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
      a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
      b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      d. Install anchor bolts to elevations required for proper attachment to supported equipment.
   6. Maintain manufacturer's recommended clearances for service and maintenance.
   7. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
   8. Install separate devices furnished by manufacturer and not factory installed.

B. Connections
1. Comply with requirements in Division 15 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements in Division 15 Section "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to chiller to allow service and maintenance.
4. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
5. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15, **as directed**.
7. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

C. Startup Service
1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
   b. Verify that pumps are installed and functional.
   c. Verify that thermometers and gages are installed.
   d. Operate water chiller for run-in period.
   e. Check bearing lubrication and oil levels.
   f. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
   g. Verify proper motor rotation.
   h. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
   i. Verify and record performance of chilled-water and condenser-water, **as directed**, flow and low-temperature interlocks.
   j. Verify and record performance of water chiller protection devices.
   k. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Prepare a written startup report that records results of tests and inspections.

END OF SECTION 15671

Task	Specification	Specification Description
15671	15655a	Rotary-Screw Water Chillers

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SECTION 15672 - RECIPROCATING WATER CHILLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for reciprocating water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Packaged, water-cooled, electric-motor-driven, reciprocating water chillers.
b. Packaged, air-cooled, electric-motor-driven, reciprocating water chillers.
c. Packaged refrigerant recovery units.

C. Definitions
1. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
2. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
3. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
4. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
5. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements
1. Seismic Performance: Reciprocating water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. Seismic Qualification Certificates: For water chillers, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
3. Source quality-control test reports.
4. Startup service reports.
5. Operation and maintenance data.
6. Warranty: Sample of special warranty.

F. Quality Assurance
1. ARI Certification: Certify chiller according to ARI 590 certification program.

2. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
3. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
4. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

G. Delivery, Storage, And Handling
1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
2. Package water chiller for export shipping.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. Packaged Water-Cooled Water Chillers
1. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
2. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
3. Compressors:
   a. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
   b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
   c. Operating Speed: 1750 rpm for 60-Hz applications.
   d. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors, **as directed**, plus hot-gas bypass, **as directed**. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
   e. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
   f. Vibration Isolation: Mount individual compressors on either neoprene or spring isolators.
   g. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
4. Compressor Motors:
   a. Hermetically sealed and cooled by refrigerant suction gas.
   b. High-torque, four-pole induction type with inherent thermal-overload protection on each phase.
5. Compressor Motor Controllers:
   a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
      OR
      Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.
6. Refrigeration:
   a. Refrigerant: R-22. Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

c. Refrigerant Circuit: Each circuit shall include a thermal **OR** an electronic, **as directed**, expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.

7. Evaporator:

a. Brazed-plate or shell-and-tube design, as indicated.

b. Shell and Tube:

1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.

2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

3) Shell Material: Carbon steel.

4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.

5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.

6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

c. Brazed Plate:

1) Direct-expansion, single-pass, brazed-plate design.

2) Type 316 stainless-steel construction.

3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

8. Condenser:

a. Shell and tube, brazed plate, or without integral condenser; as indicated.

b. Shell and Tube:

1) Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.

2) Provides positive subcooling of liquid refrigerant.

3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

4) Shell Material: Carbon steel.

5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.

6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.

7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.

c. Brazed Plate:

1) Single-pass, brazed-plate design provides positive subcooling of liquid refrigerant.

2) Type 316 stainless-steel construction.

3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.

5) Provide each condenser with a liquid-line shutoff valve.

d. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 15 Section "Air-cooled Condensers".

9. Electrical Power:
   a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
   b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
   c. Wiring shall be numbered and color-coded to match wiring diagram.
   d. Install factory wiring outside of an enclosure in a raceway.
   e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
   f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
      1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      2) NEMA KS 1, heavy-duty, nonfusible switch.
      3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   g. Provide each motor with overcurrent protection.
   h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
   i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
   j. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
   k. Control Relays: Auxiliary and adjustable time-delay relays.
   l. Indicate the following for water chiller electrical power supply:
      1) Current, phase to phase, for all three phases.
      2) Voltage, phase to phase and phase to neutral for all three phases.
      3) Three-phase real power (kilowatts).
      4) Three-phase reactive power (kilovolt amperes reactive).
      5) Power factor.
      6) Running log of total power versus time (kilowatt hours).
      7) Fault log, with time and date of each.
10. Controls:
   a. Stand-alone, microprocessor based.
   b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
   c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
      1) Date and time.
      2) Operating or alarm status.
      3) Operating hours.
      4) Outside-air temperature if required for chilled-water reset.
      5) Temperature and pressure of operating set points.
      6) Entering and leaving temperatures of chilled water.
      7) Entering and leaving temperatures of condenser water.
      8) Refrigerant pressures in evaporator and condenser.
      9) Saturation temperature in evaporator and condenser.
      10) No cooling load condition.
      11) Elapsed time meter (compressor run status).
      12) Pump status.
      13) Antirecycling timer status.
      14) Percent of maximum motor amperage.
      15) Current-limit set point.
      16) Number of compressor starts.
   d. Control Functions:
      1) Manual or automatic startup and shutdown time schedule.

2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
3) Current limit and demand limit.
4) Condenser-water temperature.
5) External water chiller emergency stop.
6) Antirecycling timer.
7) Automatic lead-lag switching.

e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1) Low evaporator pressure or high condenser pressure.
2) Low chilled-water temperature.
3) Refrigerant high pressure.
4) High or low oil pressure.
5) High oil temperature.
6) Loss of chilled-water flow.
7) Loss of condenser-water flow.
8) Control device failure.

f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
1) Hardwired Points:
a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

11. Insulation:
a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
b. Thickness: 3/4 inch (19 mm).
c. Factory-applied insulation over cold surfaces of water chiller components.
1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
d. Apply protective coating to exposed surfaces of insulation.

12. Accessories:
a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
b. Individual compressor suction and discharge pressure gages with shutoff valves.
c. Factory-furnished spring isolators for field installation.

B. Packaged Air-Cooled Water Chillers
1. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
2. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
3. Cabinet:
a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit. Base shall be designed to limit deflection to L/200 and shall be a minimum of 4 inches (100 mm) high.

b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
c. Casing: Galvanized steel.
d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
e. Sound-reduction package consisting of the following:
   1) Acoustic enclosure around compressors.
   2) Reduced-speed fans with acoustic treatment.
   3) Designed to reduce sound level without affecting performance.
f. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.

4. Compressors:
   a. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
   b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
   c. Operating Speed: 1750 rpm for 60-Hz applications.
   d. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors, plus hot-gas bypass, **as directed**. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
   e. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
   f. Vibration Isolation: Mount individual compressors on spring isolators with an isolation efficiency of 95 percent.
5. Compressor Motors:
   a. Hermetically sealed and cooled by refrigerant suction gas.
   b. High-torque, four-pole induction type with inherent thermal-overload protection on each phase.
6. Compressor Motor Controllers:
   a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
      OR
      Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.
7. Refrigeration:
   a. Refrigerant: R-22. Classified as Safety Group A1 according to ASHRAE 34.
   b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
   c. Refrigerant Circuit: Each circuit shall include a thermal **OR** an electronic, **as directed**, expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
   d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
8. Evaporator:
   a. Description: Direct-expansion shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
   b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
   c. Shell Material: Carbon steel.
   d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.

e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
g. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
h. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.

9. Air-Cooled Condenser:
   a. Plate-fin coil with integral subcooling circuit, leak tested at 150 psig (1034 kPa).
      1) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.
      2) Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
      3) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
   b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
   c. Fan Motors: Totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
   d. Fan Guards: Steel safety guards with corrosion-resistant coating.
10. Electrical Power:
   a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
   b. House in a unit-mounted, NEMA 250, Type 3R **OR** Type 4, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
   c. Wiring shall be numbered and color-coded to match wiring diagram.
   d. Install factory wiring outside of an enclosure in a raceway.
   e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
   f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
      1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      2) NEMA KS 1, heavy-duty, nonfusible switch.
      3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
   g. Provide each motor with overcurrent protection.
   h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
   i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
   j. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
      1) Power unit-mounted controls where indicated.
      2) Power unit-mounted, ground-fault interrupt (GFI) duplex receptacle.
   k. Control Relays: Auxiliary and adjustable time-delay relays.
   l. Indicate the following for water chiller electrical power supply:
      1) Current, phase to phase, for all three phases.
      2) Voltage, phase to phase and phase to neutral for all three phases.
      3) Three-phase real power (kilowatts).
      4) Three-phase reactive power (kilovolt amperes reactive).
      5) Power factor.
      6) Running log of total power versus time (kilowatt hours).
      7) Fault log, with time and date of each.
11. Controls:
   a. Stand-alone, microprocessor based.

b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
   1) Date and time.
   2) Operating or alarm status.
   3) Operating hours.
   4) Outside-air temperature if required for chilled-water reset.
   5) Temperature and pressure of operating set points.
   6) Entering and leaving temperatures of chilled water.
   7) Refrigerant pressures in evaporator and condenser.
   8) Saturation temperature in evaporator and condenser.
   9) No cooling load condition.
   10) Elapsed time meter (compressor run status).
   11) Pump status.
   12) Antirecycling timer status.
   13) Percent of maximum motor amperage.
   14) Current-limit set point.
   15) Number of compressor starts.

d. Control Functions:
   1) Manual or automatic startup and shutdown time schedule.
   2) Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
   3) Current limit and demand limit.
   4) External water chiller emergency stop.
   5) Antirecycling timer.
   6) Automatic lead-lag switching.

e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
   1) Low evaporator pressure or high condenser pressure.
   2) Low chilled-water temperature.
   3) Refrigerant high pressure.
   4) High or low oil pressure.
   5) High oil temperature.
   6) Loss of chilled-water flow.
   7) Control device failure.

f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
   1) Hardwired Points:
      a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
      b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
   2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

12. Insulation:
   a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
   b. Thickness: 3/4 inch (19 mm).

c. Factory-applied insulation over cold surfaces of water chiller components.
   1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
d. Apply protective coating to exposed surfaces of insulation.

13. Accessories:
   a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
   b. Individual compressor suction and discharge pressure gages with shutoff valves.
   c. Factory-furnished spring isolators for field installation.

C. Packaged Refrigerant Recovery Units
1. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.

D. Source Quality Control
1. Perform functional test of water chillers before shipping.
2. Factory performance test water chillers, **as directed**, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
   a. Allow Owner access to place where water chillers are being tested. Notify the Owner 14 days in advance of testing.
3. Factory test and inspect evaporator and water-cooled condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
4. For water chillers located indoors, rate sound power level according to ARI 575 procedure.
5. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

1.3 EXECUTION

A. Water Chiller Installation
1. Install water chillers on support structure indicated.
2. Equipment Mounting: Install water chiller on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install water chiller using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
4. Equipment Mounting: Install water chiller on vibration isolation inertia bases. Comply with requirements specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".

a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Maintain manufacturer's recommended clearances for service and maintenance.
7. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
8. Install separate devices furnished by manufacturer and not factory installed.

B. Connections

1. Comply with requirements in Division 15 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements in Division 15 Section "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to chiller to allow service and maintenance.
4. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
5. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15, **as directed**.
7. Connect each drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

C. Startup Service

1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
   b. Verify that pumps are installed and functional.
   c. Verify that thermometers and gages are installed.
   d. Operate water chiller for run-in period.
   e. Check bearing lubrication and oil levels.
   f. Verify that refrigerant pressure relief for chillers installed indoors is vented outside.
   g. Verify proper motor rotation.
   h. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
   i. Verify and record performance of chilled-water and condenser-water, **as directed**, flow and low-temperature interlocks.
   j. Verify and record performance of water chiller protection devices.
   k. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Prepare a written startup report that records results of tests and inspections.

END OF SECTION 15672

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Task	Specification	Specification Description
15673	15672	Reciprocating Water Chillers

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SECTION 15675 - FAN-COIL UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for fan-coil units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes fan-coil units and accessories.

C. Definitions
1. BAS: Building automation system.

D. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   a. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Compressor failure.
      2) Condenser coil leak.
   b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Substantial Completion.

c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Substantial Completion.
d. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Fan-Coil Units
1. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
2. Coil Section Insulation: 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Main and Auxiliary Drain Pans: Plastic **OR** Stainless steel **OR** Insulated galvanized steel with plastic liner, **as directed**. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004. Drain pans shall be removable, **as directed**.
4. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.
5. Cabinet: Steel with factory prime coating, ready for field painting **OR** baked-enamel finish in manufacturer's standard paint color as selected by the Owner **OR** baked-enamel finish in manufacturer's custom paint color as selected by the Owner, **as directed**.
   a. Vertical Unit Front Panels: Removable, steel, with integral stamped **OR** polyethylene **OR** steel, **as directed**, discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
   b. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped **OR** cast-aluminum, **as directed**, discharge grilles.
   c. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors. Return grille shall provide maintenance access to fan-coil unit.
   d. Steel recessing flanges for recessing fan-coil units into ceiling or wall.
6. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
   a. Louver Configuration: Horizontal **OR** Vertical, **as directed**, rain-resistant louver.
   b. Louver Material: Aluminum **OR** Steel, **as directed**.
   c. Bird Screen: 1/2-inch (13-mm) mesh screen on interior side of louver.
   d. Decorative Grille: On outside of intake.
   e. Finish: Anodized aluminum **OR** Baked enamel, **as directed**, color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.
7. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic **OR** pneumatic, **as directed**, two-position **OR** modulating, **as directed**, actuators.
8. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   a. Washable Foam: 70 percent arrestance and 3 MERV.
   b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
   c. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
9. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

10. Steam Coils: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).
11. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
12. Fan and Motor Board: Removable.
    a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
    b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
    c. Wiring Termination: Connect motor to chassis wiring with plug connection.
13. Factory, Hydronic Piping Package: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
    a. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for dual-temperature coil.
    b. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
    c. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for heating coil.
    d. Two **OR** Three, **as directed**,-way two-position **OR** modulating, **as directed**, control valve for hot-water reheat coil.
    e. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
        1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
        2) Minimum Diameter: Equal to fan-coil-unit connection size.
    f. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
    g. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250-deg F (121-deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
    h. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
    i. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
    j. Wrought-Copper Unions: ASME B16.22.
    k. Risers: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper pipe with hose and ball valve for system flushing.
14. Control devices and operational sequences are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
15. Basic Unit Controls:
    a. Control voltage transformer.
    b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features:
        1) Heat-cool-off switch.
        2) Fan on-auto switch.
        3) Fan-speed switch.

4) Manual **OR** Automatic, **as directed**, changeover.
5) Adjustable deadband.
6) Concealed **OR** Exposed, **as directed**, set point.
7) Concealed **OR** Exposed, **as directed**, indication.
8) Degree F **OR** Degree C, **as directed**, indication.

c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
1) Concealed **OR** Exposed, **as directed**, set point.
2) Concealed **OR** Exposed, **as directed**, indication.

d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.

e. Unoccupied-period-override push button.

f. Data entry and access port.
1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

16. DDC, **as directed**, Terminal Controller:

a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.

b. Unoccupied Period Override Operation: Two, **as directed**, hours.

c. Unit Supply-Air Fan Operation:
1) Occupied Periods: Fan runs continuously.
2) Unoccupied Periods: Fan cycles to maintain room setback temperature.

d. Hydronic-Cooling-Coil Operation:
1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to maintain room temperature.
2) Unoccupied Periods: Close control valve.

e. Heating-Coil Operation:
1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.

f. Dual-Temperature Hydronic-Coil Operation:
1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.

g. Reheat-Coil Operation:
1) Humidity Control for Occupied Periods:
a) Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As space temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
3) Occupied Periods:
a) Heating Operations: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
b) Humidity-Control Operations: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide

heating. As space temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.

4) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature. Humidity control is not available.

h. Outdoor-Air Damper Operation:
   1) Occupied Periods: Open damper to fixed position for 25 percent outdoor air.
   2) Unoccupied periods: Close damper.

i. Outdoor-Air Damper Operation:
   1) Occupied Periods:
      a) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below thermostat set point, position damper to fixed minimum position.
      b) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
   2) Unoccupied Periods: Close damper.

j. Controller shall have volatile-memory backup.

17. BAS Interface Requirements:
    a. Interface relay for scheduled operation.
    b. Interface relay to provide indication of fault at the central workstation.
    c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
       1) Adjust set points.
       2) Fan-coil-unit start, stop, and operating status.
       3) Data inquiry, including outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
       4) Occupied and unoccupied schedules.

18. Electrical Connection: Factory wire motors and controls for a single electrical connection.

B. Ducted Fan-Coil Units
   1. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
   2. Coil Section Insulation: 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick coated **OR** foil-faced, **as directed**, glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
      a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
      b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
   3. Drain Pans: Plastic **OR** Stainless steel **OR** Insulated galvanized steel with plastic liner, **as directed**. Fabricate pans and drain connections to comply with ASHRAE 62.1-2004.
   4. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.
   5. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
      a. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille, **as directed**.
      b. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
      c. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
      d. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
   6. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
      a. Washable Foam: 70 percent arrestance and 3 MERV.

b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
c. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

7. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.
8. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.
9. Steam Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).
10. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
11. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
    OR
    Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
    a. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
12. Factory, Hydronic Piping Package: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
    a. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
    b. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for heating coil.
    c. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for dual-temperature coil.
    d. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for reheat coil.
    e. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
        1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
        2) Minimum Diameter: Equal to fan-coil-unit connection size.
    f. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
    g. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
    h. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
    i. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
    j. Wrought-Copper Unions: ASME B16.22.
13. Remote condensing units are specified in Division 15 Section "Condensing Units".

14. Remote Condensing Units: Factory assembled and tested, consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
    a. Casing: Steel with baked-enamel finish, removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
    b. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
        1) Antirecycle timer.
        2) High-pressure cutout.
        3) Low-pressure cutout or loss-of-charge switch.
        4) Internal thermal-overload protection.
        5) Current and voltage sensitive safety devices.
    c. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
    d. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."
    e. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
    f. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
    g. Low ambient controls to permit operation down to 45 deg F (7 deg C).
    h. Crankcase heater.
    i. Charging and service fittings on exterior of casing.
    j. Filter dryer.
    k. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat operation.
    l. Hot-gas-bypass, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
    m. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
    n. Condenser Fan: Direct-drive, aluminum propeller fan.
        1) Motor: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
    o. Accessories: Polyethylene mounting base to provide a permanent foundation.
15. Control devices and operational sequence are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
16. Basic Unit Controls:
    a. Control voltage transformer.
    b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
        1) Heat-cool-off switch.
        2) Fan on-auto switch.
        3) Fan-speed switch.
        4) Manual **OR** Automatic, **as directed**, changeover.
        5) Adjustable deadband.
        6) Concealed **OR** Exposed, **as directed**, set point.
        7) Concealed **OR** Exposed, **as directed**, indication.
        8) Degree F **OR** Degree C, **as directed**, indication.
    c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
        1) Concealed **OR** Exposed, **as directed**, set point.
        2) Concealed **OR** Exposed, **as directed**, indication.
    d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
    e. Unoccupied-period-override push button.
    f. Data entry and access port.
        1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
        2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

17. DDC, **as directed**, Terminal Controller:
    a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
    b. Unoccupied Period Override Operation: Two, **as directed**, hours.
    c. Unit Supply-Air Fan Operation:
        1) Occupied Periods: Fan runs continuously.
        2) Unoccupied Periods: Fan cycles to maintain room setback temperature.
    d. Hydronic-Cooling-Coil Operation:
        1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to maintain room temperature.
        2) Unoccupied Periods: Close control valve.
    e. Refrigerant-Coil Operation:
        1) Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
        2) Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
    f. Supplemental, **as directed**, Heating-Coil Operation:
        1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
        2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
        3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below 25 deg F (4 deg C).
    g. Dual-Temperature Hydronic-Coil Operation:
        1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open **OR** modulate, **as directed**, control valve if temperature falls below thermostat set point.
        2) Unoccupied Periods: When chilled water is available, close valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
    h. Reheat-Coil Operation:
        1) Humidity Control for Occupied Periods: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
        2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
        3) Occupied Periods:
            a) Heating Operations: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
            b) Humidity-Control Operations: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
        4) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature. Humidity control is not available.
    i. Outdoor-Air Damper Operation (for fixed, minimum outdoor-air intake):
        1) Occupied Periods: Open damper to fixed position for 25 percent outdoor air.
        2) Unoccupied Periods: Close damper.
    j. Outdoor-Air Damper Operation (for outdoor-air economizer cycle based on temperature):

1) Occupied Periods:
a) Outdoor-Air Temperature below Room Temperature: If room temperature is above room-temperature set point, modulate outdoor- and return-air dampers to maintain room-temperature set point (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum setting.
b) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
k. Outdoor-Air Damper Operation (for outdoor-air economizer cycle based on enthalpy):
1) Occupied Periods:
a) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for 25 percent outdoor air.
b) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for 25 percent outdoor air.
2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
l. Controller shall have volatile-memory backup.
18. BAS Interface Requirements:
a. Interface relay for scheduled operation.
b. Interface relay to provide indication of fault at the central workstation.
c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
1) Adjust set points.
2) Fan-coil-unit start, stop, and operating status.
3) Data inquiry including outdoor-air damper position,, **as directed** supply- and room-air temperature and humidity, **as directed**.
4) Occupied and unoccupied schedules.
19. Electrical Connection: Factory wire motors and controls for a single electrical connection.

1.3 EXECUTION

A. Installation
1. Install fan-coil units level and plumb.
2. Install fan-coil units to comply with NFPA 90A.
3. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.
5. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
a. Install piping adjacent to machine to allow service and maintenance.
b. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
c. Connect condensate drain to indirect waste.
1) Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.
2. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 15 Section "Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".

4. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.

D. Adjusting
1. Adjust initial temperature and humidity set points.
2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units.

END OF SECTION 15675

Task	Specification	Specification Description
15675	15655	Centrifugal Water Chillers

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SECTION 15676 - DIRECT-FIRED ABSORPTION WATER CHILLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for direct-fired absorption water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Packaged, water-cooled, direct-fired absorption chillers.
b. Heat-exchanger, brush-cleaning system.

C. Definitions
1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. IPLV: Integrated part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by ARI 560 and referenced to ARI standard rating conditions.
4. NPLV: Nonstandard part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by ARI 560 and intended for operating conditions other than the ARI standard rating conditions.

D. Performance Requirements
1. Seismic Performance: Direct-fired absorption chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 70 deg F (21 deg C).
c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which it is installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 560:
a. Allowable Capacity Tolerance: Zero percent.
b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

E. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories, and the following:
a. Performance at ARI standard conditions and at conditions indicated.
b. Performance at ARI standard unloading conditions.
c. Minimum evaporator flow rate.

d. Absorbent capacity of chiller.
e. Refrigerant capacity of chiller.
f. Fluid capacity of evaporator and condenser.
g. Fluid capacity of generator.
h. Characteristics of safety relief devices.
i. Minimum entering condenser-fluid temperature.
j. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F (3 deg C) increments.
k. If equipped, fluid capacity of dedicated hot-water heater exchanger.
l. Combustion-air flow.
m. Exhaust gas airflow.
n. Exhaust gas minimum and maximum operating temperature.

2. LEED Submittals:
   a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1-2004.
   b. Product Data for Prerequisite EA 3: Documentation indicating that refrigerants comply.
   c. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
   c. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with area tabulated for each.
4. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   a. Structural supports.
   b. Piping roughing-in requirements.
   c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
   d. Access requirements, including working clearances for mechanical controls and electrical equipment, and clearances for tube pull and service.
5. Certificates: For certification required in "Quality Assurance" Article.
6. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Source quality-control reports.
8. Startup service reports.
9. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.
10. Warranty: Sample of special warranty.

F. Quality Assurance
   1. ARI Rating: Rate chiller performance according to requirements in ARI 560.
   2. ASHRAE Compliance:
      a. ASHRAE 15 for safety code for mechanical refrigeration.
      b. ASHRAE/IESNA 90.1-2004.
   3. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
   4. Comply with NFPA 70.

5. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
   a. UL Compliance: UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies"; and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**.

G. Delivery, Storage, And Handling
1. Ship chillers factory charged with nitrogen.
2. Ship absorbent and refrigerant in chillers or in containers separate from chillers.
   OR
   Ship absorbent and refrigerant in containers separate from chillers.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Coordination
1. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
2. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

I. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
   a. Extended warranties include, but are not limited to, the following:
      1) Complete chiller.
         OR
         Pumps and motors **OR** Purge unit **OR** Burner assembly, **as directed**.
         OR
         Absorbent **OR** Absorbent and refrigerant, **as directed**, only.
      2) Parts only **OR** only and labor, **as directed**.
      3) Loss of absorbent and refrigerant for any reason.
   b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Unit
1. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, burner assembly, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
   a. Disassemble chiller into major assemblies, as required by the installation, after factory testing and before packaging for shipment.
2. Absorbent and Refrigerant:
   a. Absorbent: Lithium bromide solution with corrosion inhibitor.
   b. Refrigerant: Deionized or distilled, **as directed**, water.
   c. Performance Enhancer: Heat and mass transfer enhancer to improve performance.
3. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

B. Pumps

1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating, tapered carbon bearings.
2. Pump motor assembly shall be designed to operate for not less than 50,000 hours between inspections.
3. Pump motors shall be cooled and bearings lubricated, either by fluid being pumped or by a filtered supply of liquid refrigerant.
4. Pump suction and discharge shall be equipped with isolation valves.
5. Absorbent solution and refrigerant shall have separate and dedicated pumps.
   a. Absorbent solution and refrigerant flow-control method shall be manufacturer's choice to comply with operating requirements indicated.
6. Purge System: Unit mounted and factory wired, equipped with controls and a pump to automatically remove noncondensable vapors.
   a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
      1) Enclosure: Open dripproof **OR** Totally enclosed, **as directed**.

C. Heat-Exchanger Shells
1. Configuration: Two shells; one shell consists of the absorber/evaporator, low-stage generator/condenser and the other shell consists of the high-stage generator. Where indicated, equip chiller with a dedicated hot-water heat exchanger.
2. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
3. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
4. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.
5. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid tube contact resulting in abrasion and wear.
6. Generator/Condenser Shell Pressure Relief Device: Manufacturer's standard rupture disk complying with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code.

D. Absorber
1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes; constructed of brass, stainless steel, or another material that will not corrode.
2. Tubes:
   a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
   b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
   c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
      1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
      2) Hinged **OR** Davited, **as directed**, water boxes.
         OR
         Hinged **OR** Davited, **as directed**, marine-type water-box covers.
   c. Standard water box without piping connections.

1) Water boxes shall have lifting lugs or eyebolts.
2) Hinged **OR** Davited, **as directed**, water boxes.

d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.

e. Thermistor or RTD temperature sensor factory installed in each nozzle.

f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

4. Additional Corrosion Protection:

a. Electrolytic corrosion-inhibitor anode.

b. Coat wetted surfaces with a corrosion-resistant finish.

OR

Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

5. Absorber/Condenser Crossover Piping: Factory-furnished and -installed piping connecting fluid connection of absorber discharge to condenser inlet.

E. Evaporator

1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode.

2. Refrigerant Holding Pan: Steel or stainless steel.

3. Tubes:

a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.

b. Material: Copper **OR** Copper-nickel alloy, **as directed**.

c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.

d. External Finish: Manufacturer's standard.

e. Internal Finish: Enhanced **OR** Smooth, **as directed**.

4. Water Boxes:

a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.

b. Standard **OR** Marine-type, **as directed**, water box with piping connections.

1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
2) Hinged **OR** Davited, **as directed**, water boxes.

OR

Hinged **OR** Davited, **as directed**, marine-type water-box covers.

c. Standard water box without piping connections.

1) Water boxes shall have lifting lugs or eyebolts.
2) Hinged **OR** Davited, **as directed**, water boxes.

d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.

e. Thermistor or RTD temperature sensor factory installed in each nozzle.

f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

F. Condenser

1. Refrigerant Holding Pan: Steel or stainless steel.

2. Tubes:

a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.

b. Material: Copper **OR** Copper-nickel alloy, **as directed**.

c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.

d. External Finish: Manufacturer's standard.
e. Internal Finish: Enhanced **OR** Smooth, **as directed**.

3. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
      1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
      2) Hinged **OR** Davited, **as directed**, water boxes.
         OR
         Hinged **OR** Davited, **as directed**, marine-type water-box covers.
   c. Standard water box without piping connections.
      1) Water boxes shall have lifting lugs or eyebolts.
      2) Hinged **OR** Davited, **as directed**, water boxes.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
   a. Electrolytic corrosion-inhibitor anode.
   b. Coat wetted surfaces with a corrosion-resistant finish.
      OR
      Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

G. First-Stage Generator
1. Tubes:
   a. Replaceable, **as directed**, straight, or U tubes expanded into tube sheets.
   b. Material: Manufacturer's standard **OR** Steel, **as directed**.
   c. Minimum Wall Thickness: Manufacturer's choice.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Manufacturer's choice; enhanced or smooth.
2. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard water box.
   c. Water boxes shall have lifting lugs or eyebolts.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

H. Second-Stage Generator
1. Tubes:
   a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
   b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
   c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Manufacturer's standard.

2. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard type.
   c. Water boxes shall have lifting lugs or eyebolts.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

I. Dedicated Hot-Water Heat Exchanger
1. Tubes:
   a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
   b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
   c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
   d. External Finish: Manufacturer's standard.
   e. Internal Finish: Manufacturer's standard.
2. Water Boxes:
   a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
   b. Standard type.
   c. Water boxes shall have lifting lugs or eyebolts.
   d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
   e. Thermistor or RTD temperature sensor factory installed in each nozzle.
   f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

J. Solution Heat Exchanger
1. Description: Shell-and-tube or brazed-plate heat exchanger, an integral part of chiller, increases cycle efficiency by preheating the weak solution on its way to the generator while precooling the strong solution returning from the generator.

K. Burner Assembly
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser suitable for natural gas **OR** propane **OR** fuel oil, **as directed**. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
2. Blower: Centrifugal fan integral to burner, directly driven by motor; with adjustable damper assembly and locking quadrant to set air-fuel ratio.
   a. Motors: Comply with requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
      1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Oil Supply: Control devices and modulating control sequence shall comply with requirements of ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
   a. Oil Pump: Two-stage, gear-type oil pump shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-in. Hg (50.7-kPa) vacuum.
   b. Oil Piping Specialties:
      1) Suction-line, manual, gate valve.
      2) Removable-mesh oil strainer.

3) 0- to 30-in. Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
5) Nozzle-line, solenoid-safety-shutoff oil valve.

4. Oil Pilot: Intermittent-electric-spark **OR** Interrupted-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
5. Gas Train: Control devices and modulating control sequence shall comply with requirements of ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
6. Gas Pilot: Intermittent-electric-spark **OR** Interrupted-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
7. Burner assembly shall be equipped to limit nitrogen oxide emissions to 20 **OR** 30, **as directed**, ppm.

L. Electrical
1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
   a. Branch power circuit to each motor, dedicated electrical load, and to controls with disconnect switch or circuit breaker, **as directed**.
      1) NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
      2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
   b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
   c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.

M. Controls
1. Chiller control panel shall be separate from burner control panel.
2. Burner Control Panel: Factory or field, **as directed**, mounted. Maintains safe operating conditions, burner safety limits, burner operation, and interface with chiller controls; include the following components:
   a. On-off switch.
   b. Flame safeguard.
   c. Contacts for remote monitoring of flame failure.
   d. Contacts for proof of combustion air.
   e. Exhaust gas temperature limit switch.
   f. Control-circuit transformer.
   g. Burner motor controls.
   h. Fuel-oil pump controls, if chiller is equipped with fuel-oil pump.
   i. Visual indication of on/off status of ignition, blower, and main fuel.
   j. Alarm bell.
3. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
4. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x, **as directed**, hinged or lockable.

5. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display the following information in either imperial or metric units selectable through the interface:
   a. Date and time.
   b. Operating or alarm status.
   c. Operating hours.
   d. Outdoor-air temperature if required for chilled-water reset.
   e. Temperature and pressure of operating set points.
   f. Entering and leaving temperatures of chilled and condenser water.
   g. Refrigerant temperature.
   h. Solution concentration and temperature.
   i. Indication of solution and purge-pump operation.
   j. Generator shell pressure.
   k. Number of starts.
   l. Number of purge cycles.
   m. Entering and leaving hot-water temperatures.
   n. Burner firing rate displayed in percent.
6. Control Functions:
   a. Manual or automatic startup and shutdown time schedule.
   b. Automatic cycle to prevent crystallization.
   c. Entering and leaving chilled-water temperatures and control set points. Chilled-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
   d. Entering and leaving hot-water temperatures and control set points. Hot-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
   e. Condenser-fluid temperature.
   f. Cooling provided and heating energy used within programmable time periods, minimum monthly.
   g. Heating provided and heating energy used within programmable time periods, minimum monthly.
7. Capacity Control: Automatically controls burner firing rate to maintain chilled-water temperature set point for cooling loads and heating-water temperature set point for heating loads ranging from 30 to 100 percent.
8. Safety Shutdowns: Chiller shall automatically shut down and require manual restart. Display a message following each safety shutdown.
   a. Crystallization.
   b. Low refrigerant temperature.
   c. Loss of chilled- or condenser-water flow.
   d. Low leaving chilled-water temperature, 2 deg F (1 deg C) below set point.
   e. First-stage generator low-solution level.
   f. First-stage generator high temperature or pressure.
   g. Burner alarm or control malfunction.
   h. Power failure.
   i. Solution pump overloads.
   j. External auxiliary safety shutdown.
   k. High solution concentration.
   l. Incomplete dilution cycle.
9. Warning Conditions: Chiller shall remain operational but inhibit burner firing rate to prevent safety shutdown. Control panel shall close warning contacts and generate a message when one of the following operating conditions is detected:
   a. Low refrigerant temperature.
   b. High generator temperature or pressure.
   c. High or low entering condenser-water temperature.
   d. Solution temperature sensor failure.
   e. Low chilled-water flow.

f. Purge-pump current overload.

10. Cycling Shutdowns: Permit automatic restart when preprogrammed limits are reached. Display a message following each cycle shutdown.
    a. Cooling Mode:
        1) Loss of condenser-water flow.
        2) Low leaving chilled-water temperature.
        3) Power failure.
    b. Heating Mode:
        1) Loss of hot-water flow.
        2) High leaving hot-water temperature.
        3) Power failure.
11. Trending: Capability to trend analog data up to five parameters simultaneously over an adjustable period and frequency of polling.
12. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
13. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
14. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.
15. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    a. Hardwired Points:
        1) Monitoring: On-off status, common trouble alarm.
        2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** hot-water, discharge temperature set-point adjustment, **as directed**.
    b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

N. Finish
1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
    a. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
    b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least 4 mils (0.10 mm).
    c. Paint surfaces that are to be insulated before applying the insulation.
    d. Paint installed insulation to match adjacent uninsulated surfaces.
    e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner.

O. Accessories
1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
2. Flow Switches:
    a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and shall verify field-mounting location before installation.
    b. Paddle Flow Switches:
        1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
        2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
        3) Pressure rating equal to pressure rating of heat exchanger.

4) Construct body and wetted parts of Type 316 stainless steel.
5) House switch in an NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
6) Vane length to suit installation.

c. Pressure Differential Switches:
1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set point shift due to variation in working pressure.
3) Set Point: Screw type, field adjustable.
4) Electrical Connections: Internally mounted, screw-type terminal blocks.
5) Switch Enclosure: NEMA 250, Type 4.
6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.

3. Vibration Isolation:
a. Chiller manufacturer shall furnish neoprene-pad vibration isolation for each chiller.
1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
2) Fabricate pads from 40- to 50-durometer neoprene.
3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

P. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser for tube cleaning and improved heat transfer.
2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
4. Components:
a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
c. Four-Way Valve:
1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
2) Configure valve with parallel flow connections to minimize field installation piping.
3) Construct valve to comply with ASME Boiler and Pressure Vessel Code , at a system working pressure equal to condenser.
4) Pipe connections shall be flanged.
5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
6) Hydrostatically test valve to 1.5 times the design working pressure.
7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
9) Valve Actuator: Mount electric actuator to operate valve.
OR
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.

10) Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.

d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:

1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
3) Manual override of preset cleaning cycle.
4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow or incomplete valve turn.
5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
6) Flow-switch bypass.
7) Unloading signal to chiller.

Q. Source Quality Control

1. Perform functional run tests of chillers before shipping.
2. Factory test and inspect absorber, generator, evaporator, and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Vacuum and pressure test shells for leaks.
3. Rate sound power level according to ARI 575.
4. Burner Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion requirements indicated.
5. Factory performance test chillers, before shipping, according to ARI 560.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.
         OR
         Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.
         OR
         At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
6. Factory sound test chillers, before shipping, according to ARI 575.
   a. Test the following conditions:
      1) Design conditions indicated.
      2) Chiller operating at calculated worst-case sound condition.
      3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by Owner at time of test.
7. Allow Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
8. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

1.3 EXECUTION

A. Examination

1. Examine chillers before installation. Reject chillers that are damaged.
2. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

a. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting (for equipment supported on concrete bases and vibration isolation devices): Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting (for equipment supported on vibration isolation devices without a concrete base): Install chiller using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
4. Equipment Mounting (for equipment installed on concrete bases without vibration isolation devices): Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Install chillers with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
7. Maintain manufacturer's recommended clearances for service and maintenance.
8. Charge chiller with absorbent and refrigerant if not factory charged.
9. Install separate devices furnished by manufacturer and not factory installed.
10. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated. Comply with requirements in Division 15 Section "Hvac Insulation".
11. Install electrical devices furnished with chiller but not specified to be factory mounted.
12. Install control wiring to field-mounted electrical devices.

C. Heat-Exchanger, Brush-Cleaning System Installation

1. Install brush-cleaning system control panel adjacent to chiller control panel.
2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
3. Provide field electric power, as required, to each system control panel and electric-actuated valve.

4. Provide pneumatic piping with pressure regulator and an isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

D. Connections
1. Comply with requirements for hydronic piping in Division 15 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements for gas piping in Division 15 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Connect gas piping full size to gas-train inlet with shutoff valve and union.
4. Install gas-fired boilers according to NFPA 54.
5. Comply with requirements for fuel-oil piping in Division 15 Section "Facility Fuel-oil Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
6. Connect oil piping full size to burner inlet with shutoff valve and union.
7. Install oil-fired boilers according to NFPA 31.
8. Install piping adjacent to chiller to allow service and maintenance.
9. Hot-Water Heat-Exchanger Connections: Connect to heat-exchanger inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to heat-exchanger outlet with shutoff valve, check valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
10. Evaporator-Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
11. Absorber/Condenser-Fluid Connections: Connect to inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
    a. If not factory furnished or installed, provide pipe connecting fluid connection of absorber discharge and condenser inlet.
12. Refrigerant Pressure Relief Device Connections: Extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
13. Extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15.
14. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.
15. Comply with requirements for chimney system in Division 15 Section "Breechings, Chimneys, And Stacks". Drawings indicate general arrangement of pipe, fittings, and specialties. Connect chimney system to chiller burner outlet and extend to the outdoors.
16. Connect fuel-fired burner assembly and blower and associated damper for combustion air.

E. Startup Service
1. Perform startup service.
    a. Complete installation and startup checks according to manufacturer's written instructions.

b. Operate chiller for run-in period.
c. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
d. Verify that pumps are installed and functional.
e. Verify that thermometers and gages are installed.
f. Operate chiller for run-in period.
g. Verify that refrigerant pressure relief device is vented to the outdoors.
h. Verify proper motor rotation.
i. Verify proper fuel supply. Adjust air-fuel ratio and combustion.
j. Verify proper combustion-air source.
k. Verify proper exhaust emissions.
l. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
m. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
n. Verify and record performance of chiller protection devices.
o. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
p. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas.

2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

F. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions, **as directed**.

END OF SECTION 15676

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Task	Specification	Specification Description
15676	15670	Indirect-Fired Absorption Water Chillers

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SECTION 15680 - COOLING TOWERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for cooling towers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Closed-circuit, forced-draft, counterflow cooling towers.
b. Closed-circuit, induced-draft, combined-flow cooling towers.
c. Closed-circuit, induced-draft, counterflow cooling towers.
d. Open-circuit, forced-draft, counterflow cooling towers.
e. Open-circuit, induced-draft, counterflow cooling towers.
f. Open-circuit, induced-draft, crossflow cooling towers.

C. Definitions
1. BMS: Building management system.
2. FRP: Fiber-reinforced polyester.

D. Performance Requirements
1. Delegated Design: Design cooling tower support structure and seismic restraints, **as directed**, and wind restraints, **as directed**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.
3. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, furnished specialties, and accessories.
a. Maximum flow rate.
b. Minimum flow rate.
c. Drift loss as percent of design flow rate.
d. Volume of water in suspension for purposes of sizing a remote storage tank.
e. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
f. Performance curves for the following:
1) Varying entering-water temperatures from design to minimum.
2) Varying ambient wet-bulb temperatures from design to minimum.
3) Varying water flow rates from design to minimum.
4) Varying fan operation (off, minimum, and design speed).
g. Fan airflow, brake horsepower, and drive losses.
h. Pump flow rate, head, brake horsepower, and efficiency.

i. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
j. Electrical power requirements for each cooling tower component requiring power.

2. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:
   a. Assembled unit dimensions.
   b. Weight and load distribution.
   c. Required clearances for maintenance and operation.
   d. Sizes and locations of piping and wiring connections.
   e. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Detail fabrication and assembly of support structure.
   b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   c. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and wind restraints, **as directed**, and for designing vibration isolation bases.
   d. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
   e. Structural supports.
   f. Piping roughing-in requirements.
   g. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
   h. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Source quality-control reports.
7. Field quality-control reports.
8. Startup service reports.
9. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
10. Warranty: Sample of special warranty.

F. Quality Assurance
1. Testing Agency Qualifications: Certified by CTI **OR** An NRTL, **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
5. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."
6. FMG approval and listing in the latest edition of FMG's "Approval Guide."

G. Coordination
1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
   a. Fan assembly including fan, drive, and motor.
   b. All components of cooling tower.
   c. Warranty Period: Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Closed-Circuit, Forced-Draft, Counterflow Cooling Towers
1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
3. Casing and Frame:
   a. Casing **OR** Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
   d. Joints and Seams: Sealed watertight.
   e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
   OR
   Collection Basin:
   a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
   c. Overflow and drain connections.
   d. Makeup water connection.
   e. Basin Sweeper Distribution Piping and Nozzles:
      1) Pipe Material: PVC.
      2) Nozzle Material: Plastic.
      3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
   OR
   Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
   a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
   b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR**

control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.

c. Electrode Probes: Stainless steel.

d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.

e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.

f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

6. Electric Basin Heater:

a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.

b. Heater Control Panel: Mounted on the side of each cooling tower cell.

c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.

d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.

e. Control-circuit transformer with primary and secondary side fuses.

f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.

g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.

h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

OR

Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

7. Water Distribution Piping: Main header and lateral branch piping designed for even distribution over fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.

b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.

c. Piping Supports: Corrosion-resistant hangers and supports designed to resist movement during operation and shipment.

8. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.

9. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.

a. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.

b. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.

c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.

d. Service Factor: 1.0 **OR** 1.15, **as directed**.

10. Heat-Exchanger Coils:

a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.

b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover

plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.
OR
ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.

c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.

11. Removable, **as directed**, Drift Eliminator:
    a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
    b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
    c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
12. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
13. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.
    a. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
    b. Fan Wheel and Housing Materials: Galvanized steel.
    c. Fan Shaft: Steel, coated to resist corrosion.
    d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
    e. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
    f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
14. Belt Drive:
    a. Belt-Drive Service Factor: 1.5 based on motor nameplate horsepower.
    b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
    OR
    Belt: One-piece, multigrooved, solid-back belt.
    d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    e. Belt-Drive Guard: Comply with OSHA regulations.
    f. Two-Motor, Single-Fan Drive:
        1) Two single-speed motors per fan, one sized for full speed and load, and the other sized for 67 percent of full-load speed.
        2) Belt Drives: Each motor shall have belt drive complying with requirements for belt drives and configured for operation when other motor fails.
        3) Motor controller and wiring same as two-speed, two-winding motor.
15. Fan Motor:
    a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.15.
    e. Insulation: Class F **OR** Class H, **as directed**.

f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."

g. Severe-duty rating with the following features:

1) Rotor and stator protected with corrosion-inhibiting epoxy resin.

2) Double-shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).

3) Internal heater automatically energized when motor is de-energized.

h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

16. Discharge Hoods:

a. Hood Configuration: Tapered **OR** Straight, **as directed**; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation, **as directed**, and access doors.

b. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.

1) Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.

17. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

18. Vibration Switch: For each fan drive.

a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.

b. Vibration Detection: Sensor with a field-adjustable acceleration sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.

c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS and, **as directed**, hardwired connection to fan motor electrical circuit.

d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS and, **as directed**, shut down the fan.

19. Controls: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".

OR

Control Package: Factory installed and wired, and functionally tested at factory before shipment.

a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.

b. Control-circuit transformer with primary and secondary side fuses.

c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.

e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.

f. Collection basin, electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.

g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.

h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.

i. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.

j. Power and controls to open discharge hood dampers when pump is energized and close dampers when pump is de-energized.

k. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.

1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

l. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.

m. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.

n. Audible alarm and silence switch.

o. Visual indication of elapsed run time, graduated in hours for each motor.

p. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
1) Operational status of each motor.
2) Position of dampers.
3) Cooling tower leaving-fluid temperature.
4) Fan vibration alarm.
5) Collection basin high **OR** low **OR** high- and low, **as directed**,-water-level alarms.

20. Personnel Access Components:

a. Doors: Large enough for personnel to access cooling tower internal components from both, **as directed**, cooling tower end walls. Doors shall be operable from both sides of the door, **as directed**.

b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.

c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.

d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard at platforms and around top of cooling tower. Comply with 29 CFR 1910.23.

e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.

B. Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.

3. Casing and Frame:

a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.

b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.

c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.

d. Joints and Seams: Sealed watertight.

e. Welded Connections: Continuous and watertight.

4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
OR
Collection Basin:

a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.

b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.

c. Overflow and drain connections.

d. Makeup water connection.
e. Basin Sweeper Distribution Piping and Nozzles:
   1) Pipe Material: PVC, **as directed**.
   2) Nozzle Material: Plastic, **as directed**.
   3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.

5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

OR

Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
c. Electrode Probes: Stainless steel.
d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

OR

Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:
a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

6. Electric Basin Heater:
a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
b. Heater Control Panel: Mounted on the side of each cooling tower cell.
c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
e. Control-circuit transformer with primary and secondary side fuses.
f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

OR

Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

7. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
   a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Location: Over each bank of fill with easily replaceable plastic, **as directed**, spray nozzles mounted in bottom of basin.
   c. Joints and Seams: Sealed watertight.
   d. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
   e. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant **OR** stainless-steel, **as directed**, hardware.
   f. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity water distribution basin.
8. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
   a. Pipe Material: PVC **OR** Galvanized steel, **as directed**.
   b. Spray Nozzle Material: Plastic **OR** Polypropylene, **as directed**.
   c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
9. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
10. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
    a. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.0 **OR** 1.15, **as directed**.
11. Fill:
    a. Materials: PVC, **as directed**, with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
    b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
    c. Fabrication: Fill-type sheets fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
    d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
12. Heat-Exchanger Coils:
    a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
    b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.
       OR
       ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.

c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.

13. Drift Eliminator:
    a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 according to ASTM E 84.
    b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
    c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
    d. Fill Drift Eliminators: Integral to **OR** Separate and removable from, **as directed**, fill.
    e. Heat-Exchanger Coil Drift Eliminators: Located on discharge side and removable.
14. Air-Intake Louvers:
    a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
    b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
    c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
    d. Location: Integral to **OR** Separate from, **as directed**, fill.
15. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
16. Axial Fan: Balanced at the factory after assembly.
    a. Blade Material: Aluminum **OR** FRP, **as directed**.
    b. Hub Material: Aluminum **OR** FRP, **as directed**.
    c. Blade Pitch: Field adjustable.
    d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
    e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
    f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
17. Belt Drive:
    a. Service Factor: 1.5 based on motor nameplate horsepower.
    b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
       OR
       Belt: One-piece, multigrooved, solid-back belt.
    d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    e. Belt-Drive Guard: Comply with OSHA regulations.
    f. Two-Motor, Single-Fan Drive:
       1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
       2) Each motor with belt drive and configured for operation when other motor fails.
       3) Controls and wiring same as two-speed, two-winding motor.
18. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
    a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
    b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
    c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
    d. Operation: Able to operate both forward and in reverse.

e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

19. Fan Motor:
    a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.15.
    e. Insulation: Class F **OR** Class H, **as directed**.
    f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
    g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
    h. Severe-duty rating with the following features:
        1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
        2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
        3) Internal heater automatically energized when motor is de-energized.
    i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
20. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
    a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
    b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
21. Vibration Switch: For each fan drive.
    a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
    c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
    d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
22. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
    a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
23. Controls: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".
    OR
    Control Package: Factory installed and wired, and functionally tested at factory before shipment.
    a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
    b. Control-circuit transformer with primary and secondary side fuses.
    c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
   1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
   2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
m. Audible alarm and silence switch.
n. Visual indication of elapsed run time, graduated in hours for each motor.
o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
   1) Operational status of each motor.
   2) Position of dampers.
   3) Cooling tower leaving-fluid temperature.
   4) Fan vibration alarm.
   5) Oil-level alarm.
   6) Collection basin high **OR** low **OR** high- and low, **as directed**,-water-level alarms.

24. Personnel Access Components:
   a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
   b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
   c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
   d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
   e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
      1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
      2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

C. Closed-Circuit, Induced-Draft, Counterflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
3. Casing and Frame:
   a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
   b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
   d. Joints and Seams: Sealed watertight.
   e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
   OR
   Collection Basin:
   a. Material: Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
   b. Overflow and drain connections.
   c. Makeup water connection.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
   OR
   Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
   a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
   b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
   c. Electrode Probes: Stainless steel.
   d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
   e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
   f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
   a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
   b. Heater Control Panel: Mounted on the side of each cooling tower cell.
   c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
   d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
   e. Control-circuit transformer with primary and secondary side fuses.
   f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
   g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
   h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

   OR
   Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
   OR
   Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
   OR

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

7. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
   a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
   b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
   c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
8. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
9. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
10. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    a. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    b. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    c. Service Factor: 1.0 **OR** 1.15, **as directed**.
11. Heat-Exchanger Coils:
    a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
    b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.
       OR
       ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
    c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
12. Removable, **as directed**, Drift Eliminator:
    a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
    b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
    c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
13. Air-Intake Louvers:
    a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
    b. UV Treatment: Treat louvers with inhibitors to protect against damage caused by UV radiation.
    c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out during all modes of operation including operation with fans off.
14. Axial Fan: Balanced at the factory after assembly.
    a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
    b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
    c. Blade Pitch: Field adjustable.
    d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
    e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus

300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.

f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

15. Belt Drive:
    a. Service Factor: 1.5 based on motor nameplate horsepower.
    b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
       OR
       Belt: One-piece, multigrooved, solid-back belt.
    d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    e. Belt-Drive Guard: Comply with OSHA regulations.
    f. Two-Motor, Single-Fan Drive:
       1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
       2) Each motor with belt drive and configured for operation when other motor fails.
       3) Controls and wiring same as two-speed, two-winding motor.
16. Fan Motor:
    a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.15.
    e. Insulation: Class F **OR** Class H, **as directed**.
    f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
    g. Severe-duty rating with the following features:
       1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
       2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
       3) Internal heater automatically energized when motor is de-energized.
    h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
17. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
    a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
    b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
18. Vibration Switch: For each fan drive.
    a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
    c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
    d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
19. Controls: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".
    OR
    Control Package: Factory installed and wired, and functionally tested at factory before shipment.

a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
b. Control-circuit transformer with primary and secondary side fuses.
c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
f. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
i. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker **OR** for each cooling tower cell, **as directed**.
   1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
   2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
j. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
k. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
l. Audible alarm and silence switch.
m. Visual indication of elapsed run time, graduated in hours for each motor.
n. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
   1) Operational status of each motor.
   2) Cooling tower leaving-fluid temperature.
   3) Fan vibration alarm.
   4) Collection basin high **OR** low **OR** high- and low, **as directed**,-water-level alarms.

20. Personnel Access Components:
   a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
   b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
   c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
   d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
   e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
      1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
      2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

D. Open-Circuit, Forced-Draft, Counterflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
3. Casing and Frame:
   a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
   d. Joints and Seams: Sealed watertight.
   e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
   OR
   Collection Basin:
   a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
   c. Overflow and drain connections.
   d. Makeup water connection.
   e. Basin Sweeper Distribution Piping and Nozzles:
      1) Pipe Material: PVC, **as directed**.
      2) Nozzle Material: Plastic, **as directed**.
      3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
6. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
   a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
   b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
   c. Electrode Probes: Stainless steel.
   d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
   e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
   f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
7. Electric Basin Heater:
   a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
   b. Heater Control Panel: Mounted on the side of each cooling tower cell.
   c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
   d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
   e. Control-circuit transformer with primary and secondary side fuses.
   f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
   g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.

h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

i. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

8. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
   a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
   b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
   c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
9. Fill:
   a. Materials: PVC, **as directed**, with maximum flame-spread index of 5 according to ASTM E 84.
   b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
   c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
   d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
10. Removable, **as directed**, Drift Eliminator:
   a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
   b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
   c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
12. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.
   a. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
   b. Fan Wheel and Housing Materials: Galvanized steel.
   c. Fan Shaft: Steel, coated to resist corrosion.
   d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
   e. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
   f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
13. Axial Fan: Balanced at the factory after assembly.
   a. Blade Material: FRP, **as directed**.
   b. Hub Material: Aluminum **OR** FRP, **as directed**.
   c. Blade Pitch: Field adjustable.
   d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
   e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
   f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

14. Belt Drive:
    a. Service Factor: 1.5 based on motor nameplate horsepower.
    b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
       OR
       Belt: One-piece, multigrooved, solid-back belt.
    d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    e. Belt-Drive Guard: Comply with OSHA regulations.
    f. Two-Motor, Single-Fan Drive:
       1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
       2) Each motor with belt drive and configured for operation when other motor fails.
       3) Controls and wiring same as two-speed, two-winding motor.
15. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
16. Fan Motor:
    a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.15.
    e. Insulation: Class F **OR** Class H, **as directed**.
    f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
    g. Severe-duty rating with the following features:
       1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
       2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and 300 deg F (minus 29 and 149 deg C).
       3) Internal heater automatically energized when motor is de-energized.
    h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
17. Discharge Hoods:
    a. Hood Configuration: Tapered **OR** Straight, **as directed**; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation, **as directed**, and access doors.
    b. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.
       1) Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.
18. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
19. Vibration Switch: For each fan drive.
    a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
    c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
    d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
20. Controls: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".
    OR

Control Package: Factory installed and wired, and functionally tested at factory before shipment.

a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
b. Control-circuit transformer with primary and secondary side fuses.
c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
f. Factory-installed and -wired, collection basin electric/electronic level controller.
g. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
h. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
i. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
j. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.
k. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
    1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
    2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
l. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
m. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
n. Audible alarm and silence switch.
o. Visual indication of elapsed run time, graduated in hours for each motor.
p. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
    1) Operational status of each motor.
    2) Position of dampers.
    3) Cooling tower leaving-fluid temperature.
    4) Fan vibration alarm.
    5) Collection basin high **OR** low **OR** high- and low, **as directed**,-water-level alarms.

21. Personnel Access Components:
    a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
    b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
    c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
    d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
    e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
        1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.

2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

E. Open-Circuit, Induced-Draft, Counterflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
3. Casing and Frame:
   a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
   b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
   c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
   d. Joints and Seams: Sealed watertight.
   e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
   OR
   Collection Basin:
   a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
   c. Overflow and drain connections.
   d. Makeup water connection.
   e. Outlet Connection: ASME B16.5, Class 150 flange.
   f. Removable equalization flume plate between adjacent cells of multiple-cell towers.
   g. Equalizer connection for field-installed equalizer piping.
   h. Basin Sweeper Distribution Piping and Nozzles:
      1) Pipe Material: PVC, **as directed**.
      2) Nozzle Material: Plastic, **as directed**.
      3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
   OR
   Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
   a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
   b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
   c. Electrode Probes: Stainless steel.
   d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
   e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
   f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
   OR
   Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:
   a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.

b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

6. Electric Basin Heater:
   a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
   b. Heater Control Panel: Mounted on the side of each cooling tower cell.
   c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
   d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
   e. Control-circuit transformer with primary and secondary side fuses.
   f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
   g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
   h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

   OR

   Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

   OR

   Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

   OR

   Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
   a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
   b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
   c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
8. Fill:
   a. Materials: CPVC **OR** PVC, **as directed**, resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
   b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
   c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
   d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
9. Removable, **as directed**, Drift Eliminator:
   a. Material: FRP **OR** PVC, **as directed**; resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
   b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
   c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
10. Air-Intake Louvers:
    a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
    b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.

c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
12. Axial Fan: Balanced at the factory after assembly.
    a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
    b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
    c. Blade Pitch: Field adjustable.
    d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
    e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
    f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
13. Belt Drive:
    a. Service Factor: 1.5 based on motor nameplate horsepower.
    b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
       OR
       Belt: One-piece, multigrooved, solid-back belt.
    d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    e. Belt-Drive Guard: Comply with OSHA regulations.
14. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
15. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
    a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
    b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
    c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
    d. Operation: Able to operate both forward and in reverse.
    e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
    f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
    g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
16. Fan Motor:
    a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.15.
    e. Insulation: Class F **OR** Class H, **as directed**.

f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
h. Severe-duty rating with the following features:
   1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
   2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).
   3) Internal heater automatically energized when motor is de-energized.
i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

17. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
    a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
    b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
18. Vibration Switch: For each fan drive.
    a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
    c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
    d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
19. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
    a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
20. Controls: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".
    OR
    Control Package: Factory installed and wired, and functionally tested at factory before shipment.
    a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
    b. Control-circuit transformer with primary and secondary side fuses.
    c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
    d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
    e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
    f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
    g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
    h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
    i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
    j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
       1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.

2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.

l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.

m. Audible alarm and silence switch.

n. Visual indication of elapsed run time, graduated in hours for each motor.

o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

1) Operational status of each motor.

2) Position of dampers.

3) Cooling tower leaving-fluid temperature.

4) Fan vibration alarm.

5) Oil-level alarm.

6) Collection basin high **OR** low **OR** high- and low, **as directed**,-water-level alarms.

21. Personnel Access Components:

a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.

b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.

c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.

d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.

e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.

2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

F. Open-Circuit, Induced-Draft, Crossflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa), **as directed**.

3. Casing and Frame:

a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.

b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.

c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.

d. Joints and Seams: Sealed watertight.

e. Welded Connections: Continuous and watertight.

4. Collection Basin: Configure tower for installation with a field-constructed collection basin.

OR

Collection Basin:

a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.

b. Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.

c. Overflow and drain connections.

d. Makeup water connection.
e. Outlet Connection: ASME B16.5, Class 150 flange.
f. Removable equalization flume plate between adjacent cells of multiple-cell towers.
g. Equalizer connection for field-installed equalizer piping.
h. Basin Sweeper Distribution Piping and Nozzles:
   1) Pipe Material: PVC, **as directed**.
   2) Nozzle Material: Plastic, **as directed**.
   3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.

5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.

OR

Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
a. Enclosures: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
c. Electrode Probes: Stainless steel.
d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

OR

Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:
a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

6. Electric Basin Heater:
a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
b. Heater Control Panel: Mounted on the side of each cooling tower cell.
c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
e. Control-circuit transformer with primary and secondary side fuses.
f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

OR

Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR

Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

OR
Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

7. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
   a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
   b. Location: Over each bank of fill with easily replaceable plastic, **as directed**, spray nozzles mounted in bottom of basin.
   c. Inlet Connection: ASME B16.5, Class 150 flange.
   d. Joints and Seams: Sealed watertight.
   e. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
   f. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant **OR** stainless-steel, **as directed**, hardware.
   g. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
   h. Single-Inlet, Field Pipe Connection: Galvanized-steel **OR** PVC, **as directed**, pipe arranged to provide balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for mating to ASME B16.5, Class 150 flange and located on the bottom **OR** side, **as directed**, unless otherwise indicated.
8. Fill:
   a. Materials: PVC, with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
   b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
   c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
   d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
9. Drift Eliminator:
   a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
   b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
   c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
   d. Location: Integral to **OR** Separate and removable from, **as directed**, fill.
10. Air-Intake Louvers:
   a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
   b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
   c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
   d. Location: Integral to **OR** Separate from, **as directed**, fill.
11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**,-steel wire mesh.
12. Axial Fan: Balanced at the factory after assembly.
   a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
   b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
   c. Blade Pitch: Field adjustable.
   d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
   e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus

300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.

f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

13. Belt Drive:
    a. Service Factor: 1.5 based on motor nameplate horsepower.
    b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
    c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
       OR
       Belt: One-piece, multigrooved, solid-back belt.
    d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
    e. Belt-Drive Guard: Comply with OSHA regulations.
    f. Two-Motor, Single-Fan Drive:
       1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
       2) Each motor with belt drive and configured for operation when other motor fails.
       3) Controls and wiring same as two-speed, two-winding motor.
14. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
    a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
    b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
    c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
    d. Operation: Able to operate both forward and in reverse.
    e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
    f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
    g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
15. Fan Motor:
    a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    d. Service Factor: 1.15.
    e. Insulation: Class F **OR** Class H, **as directed**.
    f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
    g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
    h. Severe-duty rating with the following features:
       1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
       2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).

3) Internal heater automatically energized when motor is de-energized.

i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

16. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
    a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
    b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
17. Vibration Switch: For each fan drive.
    a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
    c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
    d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
18. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
    a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
19. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
20. Controls: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".
    OR
    Control Package: Factory installed and wired, and functionally tested at factory before shipment.
    a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
    b. Control-circuit transformer with primary and secondary side fuses.
    c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
    d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
    e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
    f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
    g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
    h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
    i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
    j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
        1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
        2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
    k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
    l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
    m. Audible alarm and silence switch.
    n. Visual indication of elapsed run time, graduated in hours for each motor.

o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
   1) Operational status of each motor.
   2) Position of dampers.
   3) Cooling tower leaving-fluid temperature.
   4) Fan vibration alarm.
   5) Oil-level alarm.
   6) Collection basin high **OR** low **OR** high- and low, **as directed**,-water-level alarms.

21. Personnel Access Components:
   a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
   b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
   c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
   d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
   e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
      1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
      2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

G. Source Quality Control
   1. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."
   2. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

1.3 EXECUTION

A. Examination
   1. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.
      a. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
   2. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation
   1. Install cooling towers on support structure indicated.
   2. Equipment Mounting: Install cooling tower on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
      a. Minimum Deflection: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
      b. Provide galvanized **OR** stainless, **as directed**,-steel plate to equally distribute weight over elastomeric pad.

c. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
d. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
e. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3. Equipment Mounting: Install cooling tower using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
   b. Provide galvanized **OR** stainless, **as directed**,-steel plate to equally distribute weight over elastomeric pad.
4. Equipment Mounting: Install cooling tower on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Maintain manufacturer's recommended clearances for service and maintenance.
7. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

C. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to cooling towers to allow service and maintenance.
3. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
4. Provide drain piping with valve at cooling tower drain connections and at low points in piping.
5. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
6. Domestic Water Piping: Comply with applicable requirements in Division 15 Section "Domestic Water Piping". Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.
7. Supply and Return Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping". Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union **OR** flange **OR** mechanical coupling, **as directed**.
8. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.
9. Hot-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping". Connect to supply and return basin heater with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection. Provide supply and return piping with pressure gage and thermometer.
10. Steam and Condensate Piping: Comply with applicable requirements in Division 15 Section "Steam And Condensate Piping". Connect steam supply to basin heater with shutoff valve, strainer, control valve, and union or flange and condensate piping with union or flange, shutoff valve, strainer, and an appropriate steam trap.

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections: Comply with ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment **OR** CTI ATC 105, "Acceptance Test Code for Water Cooling Towers", **as directed**.
3. Cooling towers will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

E. Startup Service
1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Obtain performance data from manufacturer.
   a. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
      1) Clean entire unit including basins.
      2) Verify that accessories are properly installed.
      3) Verify clearances for airflow and for cooling tower servicing.
      4) Check for vibration isolation and structural support.
      5) Lubricate bearings.
      6) Verify fan rotation for correct direction and for vibration or binding and correct problems.
      7) Adjust belts to proper alignment and tension.
      8) Verify proper oil level in gear-drive housing. Fill with oil to proper level.
      9) Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
      10) Check vibration switch setting. Verify operation.
      11) Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
      12) Verify operation of basin heater and control.
      13) Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
      14) Replace defective and malfunctioning units.
4. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
5. Prepare a written startup report that records the results of tests and inspections.

F. Adjusting
1. Set and balance water flow to each tower inlet.
2. Adjust water-level control for proper operating level.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 15680

Task	Specification	Specification Description
15681	15680	Cooling Towers
15684	01352	No Specification Required

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SECTION 15699 - REFRIGERANT DETECTION AND ALARM

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for refrigerant detection and alarm. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes refrigerant monitors, notification appliances, and SCBA.

C. Definitions
1. CMOS: Complementary metal-oxide semiconductor.
2. LCD: Liquid-crystal display.
3. LED: Light-emitting diode.
4. MOS: Metal-oxide semiconductor.
5. NDIR: Non-dispersive infrared.
6. PIR: Photoacoustic infrared.
7. SCBA: Self-contained breathing apparatus.

D. Submittals
1. Product Data:
   a. For each type of refrigerant monitor, include refrigerant sensing range in ppm, temperature and humidity range, alarm outputs, display range, furnished specialties, installation requirements, and electric power requirement.
   b. For SCBA, include mounting details, service requirements, and compliance with authorized Federal agency.
2. Shop Drawings:
   a. Air-Sampling Tubing: Size, routing, and termination including elevation above finished floor.
   b. Wiring Diagrams: Power, signal, and control wiring.
3. Product Certificates: For monitoring devices and SCBA, signed by product manufacturer.
4. Field quality-control test reports.
5. Operation and maintenance data.

1.2 PRODUCTS

A. CMOS **OR** MOS, **as directed**, Refrigerant Monitor
1. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, shutting down fuel-fired equipment, **as directed**, and automatically activating ventilation system.
2. ASHRAE: Monitoring system shall comply with ASHRAE 15.
3. Performance:
   a. Refrigerant to Be Monitored: R-22 **OR** R-134a **OR** R-407C **OR** R-410A, **as directed**.
   b. Range: 0 to 1000 ppm.
   c. Minimum Detectability: 50 ppm, **as directed**.
   d. Accuracy: Maximum 10 percent of full scale.
   e. Repeatability: Maximum plus or minus 2 percent of full scale.
   f. Response: Maximum 150 seconds for 90 percent of full scale, and 20-second step change.
   g. Detection Level Set Points:

1) Detection Level 1: 50 ppm, **as directed**.
2) Detection Level 2: 250 ppm, **as directed**.

h. Operating Temperature: 32 to 104 deg F (0 to 40 deg C).
i. Relative Humidity: 20 to 95 percent, noncondensing over the operating temperature range.
j. Site Elevation: Maximum 6560 feet (2000 m), **as directed**.

4. Input/Output Features:
   a. Maximum Power Input: 120-V ac, 60 Hz, 75 W.
   b. Number of Sensor/Transmitter Points: One **OR** Four, **as directed**.
   c. Alarm Relays: Minimum 3 relays at a minimum of 5-A resistive load each.
   d. Alarm Set Points: Displayed and adjustable through keypad on front of meter.
   e. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.
   f. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.
   g. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.
   h. Audible Output: Minimum 75 dB at 10 feet (3 m).
   i. Visible Output: Strobe light.
   j. Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.
   k. Serial Output: RS-232 or RS-485 compatible with HVAC controls, **as directed**.
   l. Enclosure: NEMA 250, Type 1 **OR** Type 12, **as directed**, with locking quarter-turn latch and key.

B. NDIR Refrigerant Monitor
1. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, shutting down fuel-fired equipment, **as directed**, and automatically activating ventilation system.
2. ASHRAE: Monitoring system shall comply with ASHRAE 15.
3. Performance:
   a. Refrigerant to Be Monitored: R-22 **OR** R-123 **OR** R-134a **OR** R-407C **OR** R-410A, **as directed**.
   b. Range: 0 to 1000 ppm.
   c. Sensitivity:
      1) Minimum Detectability: 10 ppm, **as directed**.
      2) Accuracy: 0 to 100 ppm; plus or minus 10 ppm. 100 to 1000 ppm; plus or minus 10 percent of reading.
      3) Repeatability: Plus or minus 1 percent of full scale.
      4) Response: Maximum 10, **as directed**, seconds per sample.
      5) Detection Level Set Points:
         a) Detection Level 1: 1 ppm, **as directed**.
         b) Detection Level 2 **OR** Level 1, **as directed**: 10 **OR** 50, **as directed**, ppm.
         c) Detection Level 3 **OR** Level 2, **as directed**: 50 **OR** 250, **as directed**, ppm.
   d. Sensitivity:
      1) Minimum Detectability: 20 ppm, **as directed**.
      2) Accuracy: 0 to 100 ppm; plus or minus 20 ppm, 100 to 1000 ppm; plus or minus 5 percent of reading.
      3) Repeatability: Plus or minus 1 percent of full scale.
      4) Response: 50 percent of a step change in 60 seconds.
      5) Detection Level Set Points:
         a) Detection Level 1: 20 ppm, **as directed**.
         b) Detection Level 2 **OR** Level 1, **as directed**: 50 ppm, **as directed.**
         c) Detection Level 3 **OR** Level 2, **as directed**: 250 ppm, **as directed**.
   e. Operating Temperature: 32 to 104 deg F (0 to 40 deg C).

f. Relative Humidity: 20 to 95 percent, noncondensing over the operating temperature range. Compensate sensor for relative humidity, **as directed**.
g. Site Elevation: Maximum 6560 feet (2000 m), **as directed**.

4. Input/Output Features:
   a. Maximum Power Input: 120-V ac, 60 Hz, 75 W.
   b. Number of Air-Sampling Points: One **OR** Four **OR** Eight **OR** 16, **as directed**.
   c. Air-Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.
   d. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.
   e. Alarm Relays: Minimum 3 **OR** 4, **as directed**, relays at a minimum of 5-A resistive load each.
   f. Alarm Set Points: Displayed on front of meter and adjustable through keypad on front of meter.
   g. Alarm Acknowledge Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.
   h. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.
   i. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault LEDs.
   j. Audible Output: Minimum 75 dB at 10 feet (3 m).
   k. Visible Output: Strobe light.
   l. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.
   m. Serial Output: RS-232 or RS-485 compatible with HVAC controls, **as directed**.
   n. Enclosure: NEMA 250, Type 1 **OR** Type 12, **as directed**, with locking quarter-turn latch and key.

C. PIR Refrigerant Monitor
1. Description: Sensor shall be factory tested, calibrated, and certified to continuously measure and display the specific gas concentration and shall be capable of indicating, alarming, shutting down fuel-fired equipment, **as directed**, and automatically activating ventilation system.
2. ASHRAE: Monitoring system shall comply with ASHRAE 15 and ASHRAE 147, **as directed**.
3. Performance:
   a. Refrigerant to Be Monitored: R-22 **OR** R-123 **OR** R-134a **OR** R-407C **OR** R-410A, **as directed**.
   b. Range: 0 to 1000 ppm.
   c. Sensitivity:
      1) Minimum Detectability: 1 ppm, **as directed**.
      2) Accuracy: 0 to 50 ppm; plus or minus 1 ppm. 51 to 1000 ppm; plus or minus 10 percent of reading.
      3) Repeatability: Plus or minus 1 percent of full scale.
      4) Response: Maximum 10, **as directed,** seconds per sample.
      5) Detection Level Set Points:
         a) Detection Level 1: 1 ppm, **as directed**.
         b) Detection Level 2 **OR** Level 1, **as directed**: 10 **OR** 50, **as directed,** ppm.
         c) Detection Level 3 **OR** Level 2, **as directed**: 50 **OR** 250, **as directed,** ppm.
   d. Sensitivity:
      1) Minimum Detectability: 20 ppm, **as directed**.
      2) Accuracy: 0 to 100 ppm; plus or minus 20 ppm, 100 to 1000 ppm; plus or minus 5 percent of reading.
      3) Repeatability: Plus or minus 1 percent of full scale.
      4) Response: 50 percent of a step change in 60 seconds.
      5) Detection Level Set Points:
         a) Detection Level 1: 20 ppm, **as directed**.
         b) Detection Level 2 **OR** Level 1, **as directed**: 50 ppm, **as directed**.
         c) Detection Level 3 **OR** Level 2, **as directed**: 250 ppm, **as directed**.

e. Operating Temperature: 32 to 104 deg F (0 to 40 deg C).
f. Relative Humidity: 20 to 95 percent, noncondensing over the operating temperature range. Compensate sensor for relative humidity.
g. Site Elevation: Maximum 6560 feet (2000 m), **as directed**.

4. Input/Output Features:
   a. Maximum Power Input: 120-V ac, 60 Hz, 75 W.
   b. Number of Air-Sampling Points: One **OR** Four **OR** Eight **OR** 16, **as directed**.
   c. Air-Sampling Point Inlet Filter: 0.10-micron filter element for each sampling point.
   d. Air-Sampling Point Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms matched to sensor output.
   e. Alarm Relays: Minimum 3 **OR** 4, **as directed,** relays at a minimum of 5-A resistive load each.
   f. Alarm Set Points: Displayed and adjustable through keypad on front of meter.
   g. Alarm Silence Switch: Mount in the front panel of the monitor to stop audible and visual notification appliances, but alarm LED remains illuminated.
   h. Alarm Manual Reset: Momentary-contact push button in the front panel of the monitor stops audible and visual notification appliances, extinguishes alarm LED, and returns monitor to detection mode at current detection levels.
   i. Display: Alphanumeric LCD, LED indicating lights for each detection level; acknowledge switch and test switch mounted on front panel; alarm status LEDs and service fault/trouble LEDs.
   j. Audible Output: Minimum 75 dB at 10 feet (3 m).
   k. Visible Output: Strobe light.
   l. Sensor Analog Output: 0- to 10-V dc into 2k ohms, or 4- to 20-mA into 1k ohms.
   m. Serial Output: RS-232 or RS-485 compatible with HVAC controls, **as directed**.
   n. Enclosure: NEMA 250, Type 1 **OR** Type 12, **as directed**, with locking quarter-turn latch and key.

D. Monitor Alarm Sequence
1. Detection Level 1: Notify HVAC control workstation of detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Start ventilation system at low speed to allow occupancy by maintenance technicians to identify leaks. Cycle blue strobe lights.
2. Detection Level 2 **OR** Level 1, **as directed**: Notify the HVAC control workstation of the detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Run ventilation system at high speed on a rise in concentration to this level, and change to low speed on a reduction in concentration below this level. Operate the ventilation system at high speed for a minimum of five minutes. Cycle amber strobe lights.
3. Detection Level 3 **OR** Level 2, **as directed**: Notify the HVAC control workstation of the detection in the refrigeration equipment room on a rise or fall of refrigerant concentration to this level. Sound alarm horns and cycle red strobe lights inside and outside refrigeration equipment room. Terminate operation of any combustion-process equipment located in the refrigeration equipment room. Provide manual reset for this detection level.
4. Sensor Fault/Trouble: Notify HVAC control workstation of fault/trouble detection in monitor.

E. Notification Appliances
1. Horns: Comply with UL 464; electric-vibrating-polarized type, listed by a qualified testing agency with provision for housing the operating mechanism behind a grille. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn.
2. Visible Alarm Devices: Comply with UL 1971; three color xenon strobe lights, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The words "REFRIGERANT DETECTION" printed in minimum 1/2-inch- (13-mm-) high letters on the lens. Rated light output is 75 **OR** 110, **as directed,** candela.

F. Air-Sampling Tubing
1. Annealed-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

2. Polyethylene Tubing: ASTM D 2737, flame-retardant, nonmetallic tubing rated for ambient temperature range of 10 to 150 deg F (minus 13 to plus 65 deg C).

G. SCBA

1. Description: Open-circuit, pressure-demand, compressed-air SCBA; includes completely assembled, portable, self-contained devices designed for application in hazardous breathing environment. Tested and certified by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration according to 42 CFR 84, Subpart H.
2. Face Piece: Silicon, EPDM, or nitrile rubber], one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in mask, close-fitting nose piece to ensure no CO_2 buildup, and perspiration drain to avoid skin irritation and prevent lens fogging.
3. Backplate: Ergonomically designed of glass fiber, aluminum, or thermoset plastic.
4. Harness and Carrier Assembly: Large triangular back pad, with backplate and adjustable waist and shoulders straps. Modular design, detachable components, easy to clean and maintain. Shoulder straps are padded with flame-resistant material, reinforced with stainless-steel cable, and attached with T-nuts, washers, and screws.
5. Air Cylinder, Regulator, and Pressure Gages: 30 **OR** 45 **OR** 60, **as directed**,-minute, low-pressure 2216-psig (15.3-MPa), carbon-fiber composite, fiberglass composite, or all-aluminum cylinders fitted with quick-fill assembly for refilling and air transfer. Two-stage regulator, and gage with end of service time whistle signal.
6. Wall-Mounted Case: Watertight, high visibility orange or yellow, **as directed**, corrosion-resistant, tough, lockable plastic case.

1.3 EXECUTION

A. Installation

1. Comply with ASHRAE 15 and ASHRAE 147, **as directed**.
2. Install air-sampling inlets, or diffusion type monitors in pits, tunnels, or trenches in machinery room that are accessible to personnel.
3. Floor mount diffusion-type monitor, sensor/transmitters, or air-sampling inlets on slotted channel frame 12 to 18 inches (300 to 450 mm) above the floor in a location near the refrigerant source or between the refrigerant source and the ventilation duct inlet.
4. Wall mount air-sampling multiple-point monitors with top of unit 60 inches (1525 mm) above finished floor.
5. Run air-sampling tubing from monitor to air-sampling point, in size as required by monitor manufacturer. Install tubing with maximum unsupported length of 36 inches (915 mm), for tubing exposed to view. Terminate air-sampling tubing at sampling point with filter recommended by monitor manufacturer.
6. Install air-sampling tubing with sufficient slack and flexible connections to allow for vibration of tubing and movement of equipment.
7. Purge air-sampling tubing with dry, oil-free compressed air before connecting to monitor.
8. Number-code or color-code air-sampling tubing for future identification and service of air-sampling multiple-point monitors.
9. Extend air-sampling tubing from exhaust part of multiple-point monitors to outside.
10. Extend air-sampling tubing from outdoors to outdoor inlet connection of NDIR monitors. Terminate air-sampling tubing at outdoor inlet location with filter recommended by monitor manufacturer.
11. Install warning signs, labels, and nameplates to identify detection devices according to Division 15 Section "Identification For Hvac Piping And Equipment".
12. Place warning signs inside and outside each door to the refrigeration equipment room. Sample wording: "AUDIBLE AND VISUAL ALARM SOUNDING INDICATES REFRIGERANT DETECTION - ENTRY REQUIRES SELF-CONTAINED BREATHING APPARATUS."

13. Audible Alarm-Indicating Devices: Install at each entry door to refrigeration equipment room, and position not less than 6 inches (150 mm) below the ceiling. Install horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
14. Visible Alarm-Indicating Devices: Install adjacent to each alarm horn at each entry door to refrigeration equipment room, and position at least 6 inches (150 mm) below the ceiling.
15. Mount primary and secondary backup, **as directed,** SCBA on wall outside each, **as directed,** interior door to refrigeration equipment room.

B. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
3. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
   a. Inspect field-assembled components, equipment installation, and electrical connections for compliance with requirements.
   b. Test and adjust controls and safeties.
   c. Test Reports: Prepare a written report to record the following:
      1) Test procedures used.
      2) Test results that comply with requirements.
      3) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
5. Repair or replace malfunctioning units and retest as specified above.

C. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain refrigerant detection devices and SCBA equipment.
2. SCBA Training: Provide an instructional video that details operating procedures of equipment.

END OF SECTION 15699

Task	Specification	Specification Description
15699	15061h	Refrigerant Piping
15699	15661	Condensing Units
15715	15061g	Steam And Condensate Piping

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SECTION 15732 - HEAT EXCHANGERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hydronic and steam heat exchangers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes shell-and-tube and plate heat exchangers.

C. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   a. Tube-removal space.
   b. Structural members to which heat exchangers will be attached.
3. Manufacturer Seismic Qualification Certification: Submit certification that heat exchanger, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

D. Quality Assurance
1. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.2 PRODUCTS

A. Shell-And-Tube Heat Exchangers
1. Configuration: U-tube with removable bundle.
2. Shell Materials: Steel.
3. Head:
   a. Materials: Cast iron **OR** Cast stainless steel **OR** Fabricated steel **OR** Fabricated steel with removable cover **OR** Fabricated stainless steel **OR** Fabricated stainless steel with removable cover, **as directed**.
   b. Flanged and bolted to shell.
4. Tube:
   a. Seamless copper **OR** Steel **OR** Stainless-steel **OR** Cupronickel **OR** Admiralty-metal, **as directed,** tubes.
   b. Tube diameter is determined by manufacturer based on service.
5. Tubesheet Materials: Steel **OR** Stainless-steel, **as directed,** tubesheets.
6. Baffles: Steel **OR** Stainless steel, **as directed**.
7. Piping Connections:
   a. Shell: Flanged inlet and threaded **OR** Threaded inlet and **OR** Flanged inlet and, **as directed,** outlet fluid connections, threaded drain, and vent connections.
   b. Head: Threaded **OR** Flanged, **as directed,** inlet and outlet fluid connections.
8. Support Saddles:
   a. Fabricated of material similar to shell.
   b. Foot mount with provision for anchoring to support.

c. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger saddles are anchored to building structure.

B. Gasketed Plate Heat Exchangers
1. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.
2. Frame:
   a. Capacity to accommodate 20 percent additional plates.
   b. Painted carbon steel with provisions for anchoring to support.
3. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
   a. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger carrying and guide bars are anchored to building structure.
4. End-Plate Material: Painted carbon steel.
5. Tie Rods and Nuts: Steel or stainless steel.
6. Plate Material: 0.024 inch (0.6 mm) **OR** 0.031 inch (0.8 mm) **OR** 0.039 inch (1 mm), **as directed,** thick before stamping; Type 304 **OR** 304L **OR** 316 **OR** 316L, **as directed,** stainless steel.
7. Gasket Material: Nitrile rubber **OR** EPDM, **as directed**.
8. Piping Connections:
   a. Threaded port for NPS 2 (DN 50) and smaller. For larger sizes, furnish end-plate port with threaded studs suitable for flanged connection.
   b. End plate with welded carbon-steel nozzles. Threaded pipe connection for NPS 2 (DN 50) and smaller; carbon-steel flanged pipe connection for larger sizes.
   c. Line wetted surfaces with same material as plates.
9. Enclose plates in a solid aluminum **OR** stainless-steel, **as directed,** removable shroud.

C. Brazed Plate Heat Exchangers
1. Configuration: Brazed assembly consisting of two end plates, one with threaded nozzles and pattern-embossed plates.
2. End-Plate Material: Type 316 stainless steel.
3. Threaded Nozzles: Type 316 stainless steel.
4. Plate Material: Type 316 stainless steel.
5. Brazing Material: Copper or nickel.

1.3 EXECUTION

A. Heat-Exchanger Installation
1. Install shell-and-tube heat exchangers on saddle supports.
2. Install shell-and-tube heat exchangers on, and anchor to, concrete base.

B. Connections
1. Install shutoff valves at heat-exchanger inlet and outlet connections.
2. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
3. Install vacuum breaker at heat-exchanger steam inlet connection.
4. Install hose end valve to drain shell.

END OF SECTION 15732

SECTION 15734 - AIR-TO-AIR ENERGY RECOVERY UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for air-to-air energy recovery equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Heat wheels.
b. Heat-pipe heat exchangers.
c. Fixed-plate sensible heat exchangers.
d. Fixed-plate total heat exchangers.
e. Packaged energy recovery units.

C. Performance Requirements
1. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals
1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittals:
a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Detail fabrication and assembly of air-to-air energy recovery equipment.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
c. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
a. Suspended ceiling components.

b. Structural members to which equipment or suspension systems will be attached.

6. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control reports.
8. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ARI Compliance:
   a. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
   b. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."
3. ASHRAE Compliance:
   a. Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
   b. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
4. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
5. UL Compliance:
   a. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
   b. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

F. Coordination
1. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
2. Coordinate sizes and locations of concrete bases with actual equipment provided.
3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Packaged Energy Recovery Units: Two years.
   b. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

1.2 PRODUCTS

A. Heat Wheels
1. Casing:
   a. Steel with standard factory-painted finish.

b. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
c. Casing seals on periphery of rotor and on duct divider and purge section.
d. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing.

2. Rotor: Aluminum segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating, **as directed**.
   a. Maximum Solid Size for Media to Pass: 500 **OR** 800 **OR** 1200, **as directed**, micrometer.
3. Rotor: Glass-fiber **OR** Polymer, **as directed**, segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
   a. Maximum Solid Size for Media to Pass: 800 **OR** 1200, **as directed**, micrometer.
4. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, **as directed**, and self-adjusting multilink belt around outside of rotor.
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
5. Controls:
   a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
   b. Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.
      OR
      Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
      OR
      Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and, **as directed**, air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
   c. Pilot-Light Indicator: Display rotor rotation and speed.
   d. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
6. Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, viscous-coated, flat-panel type.
   d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
   e. Minimum Arrestance: 80, according to ASHRAE 52.1.
   f. Minimum Merv: 5, according to ASHRAE 52.2.
   g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
   h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
7. Extended-Surface, Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface type.
   d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
   e. Minimum Arrestance: 90, according to ASHRAE 52.1.
   f. Minimum Merv: 7, according to ASHRAE 52.2.

g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

8. Extended-Surface, Nonsupported-Media Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface, self-supporting type.
   d. Minimum Arrestance: 95, according to ASHRAE 52.1.
   e. Minimum Merv: 13, according to ASHRAE 52.2.
   f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
   g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
   h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.

B. Heat-Pipe Heat Exchangers
1. Casing: Galvanized-steel flanged casing, with airtight partition between airstreams.
2. Refrigerant: ASHRAE 15, Group 1..
3. Tubes: 5/8-inch- (16-mm-) **OR** 1-inch- (25-mm-), **as directed**, diameter, aluminum **OR** copper, **as directed**.
4. Fins: Aluminum **OR** Integral aluminum **OR** Copper, **as directed**.
   a. Fin Spacing: 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
   b. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
5. Coating: Thermoplastic vinyl **OR** Epoxy **OR** Synthetic resin **OR** Phenolic **OR** Polytetrafluoroethylene **OR** Vinyl ester, **as directed**; apply to supply and exhaust.
6. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.
   OR
   Control: Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.

C. Fixed-Plate Sensible Heat Exchangers
1. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Casing: Aluminum **OR** Galvanized steel **OR** Enameled steel, with galvanized-steel liner **OR** Enameled steel, **as directed**, with duct collars.
3. Casing Insulation: 1/2-inch- (13-mm-) thick, foil-faced glass fiber **OR** 1-inch- (25-mm-) thick, foil-faced glass fiber **OR** 1 inch (25 mm) thick, ASTM C 1071 with coated surface **OR** 1 inch (25 mm) thick, fiber free, **as directed**.
4. Drain Pan: Same material as casing, with drain connections on exhaust and supply side **OR** Molded ABS covering bottom of case, with drain connections on exhaust and supply side, ,**as directed**.
   a. Comply with requirements in ASHRAE 62.1-2004.
5. Plates: Evenly spaced and sealed and arranged for counter airflow.
   a. Plate Material: Embossed aluminum **OR** Stainless steel **OR** Polypropylene copolymer (high-density plastic), **as directed**.
   b. Plate Coating: Epoxy **OR** Air-dried phenolic, **as directed**.

6. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
7. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection, **as directed**.
8. Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, viscous-coated, flat-panel type.
   d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
   e. Minimum Arrestance: 80, according to ASHRAE 52.1.
   f. Minimum Merv: 5, according to ASHRAE 52.2.
   g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
   h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
9. Extended-Surface, Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface type.
   d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
   e. Minimum Arrestance: 90, according to ASHRAE 52.1.
   f. Minimum Merv: 7, according to ASHRAE 52.2.
   g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
   h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
   i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
10. Extended-Surface, Nonsupported-Media Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface, self-supporting type.
   d. Minimum Arrestance: 95, according to ASHRAE 52.1.
   e. Minimum Merv: 13, according to ASHRAE 52.2.
   f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
   g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
   h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.

D. Fixed-Plate Total Heat Exchangers
1. Casing: Galvanized steel.
2. Plates: Evenly spaced and sealed and arranged for counter airflow.
   a. Plate Material: Chemically treated paper with selective hydroscopicity and moisture permeability, and gas barrier properties.
3. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
4. Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

c. Factory-fabricated, viscous-coated, flat-panel type.
d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
e. Minimum Arrestance: 80, according to ASHRAE 52.1.
f. Minimum Merv: 5, according to ASHRAE 52.2.
g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

5. Extended-Surface, Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface type.
   d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
   e. Minimum Arrestance: 90, according to ASHRAE 52.1.
   f. Minimum Merv: 7, according to ASHRAE 52.2.
   g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
   h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
   i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

E. Packaged Energy Recovery Units
1. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and calked weathertight, **as directed**, hinged access doors **OR** removable panels, **as directed**, with neoprene gaskets for inspection and access to internal parts, minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
   a. Inlet: Weatherproof hood **OR** louver, **as directed**, with damper for exhaust and supply.
      1) Exhaust: Gravity backdraft damper **OR** Spring-return, two-position, motor-operated damper, **as directed**.
      2) Supply: Gravity backdraft damper **OR** Spring-return, two-position, motor-operated damper, **as directed**.
   b. Roof Curb: Refer to Division 07 Section "Roof Accessories" for roof curbs and equipment supports.
3. Heat Recovery Device: Heat wheel **OR** Heat-pipe heat exchanger **OR** Fixed-plate heat exchanger, **as directed**.
4. Supply and Exhaust Fans: Forward-curved, centrifugal **OR** Propeller **OR** Backward-inclined, SWSI centrifugal **OR** Backward-inclined, plenum centrifugal, **as directed**, fan with spring isolators **OR** restrained, spring isolators **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, and insulated, **as directed**, flexible duct connections.
   a. Motor and Drive: Direct driven **OR** Belt driven with adjustable sheaves, motor mounted on adjustable base **OR** Drive type indicated on Drawings, **as directed**.
   b. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.
   e. Spring isolators on each fan having 1-inch (25-mm) static deflection.
5. Disposable Panel Filters:
   a. Comply with NFPA 90A.

b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
c. Factory-fabricated, viscous-coated, flat-panel type.
d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
e. Minimum Arrestance: 80, according to ASHRAE 52.1.
f. Minimum Merv: 5, according to ASHRAE 52.2.
g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

6. Extended-Surface, Disposable Panel Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface type.
   d. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
   e. Minimum Arrestance: 90, according to ASHRAE 52.1.
   f. Minimum Merv: 7, according to ASHRAE 52.2.
   g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
   h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
   i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
7. Extended-Surface, Nonsupported-Media Filters:
   a. Comply with NFPA 90A.
   b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
   c. Factory-fabricated, dry, extended-surface, self-supporting type.
   d. Minimum Arrestance: 95, according to ASHRAE 52.1.
   e. Minimum Merv: 13, according to ASHRAE 52.2.
   f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
   g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
   h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
8. Cooling Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
   a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
   b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
   c. Tubes: Copper.
   d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
   e. Fins: Aluminum **OR** Copper, **as directed**.
   f. Fin and Tube Joint: Mechanical bond.
   g. Leak Test: Coils shall be leak tested with air under water.
   h. Refrigerant Coils:
      1) Capacity Reduction: Circuit coils for face **OR** row **OR** interleaved, **as directed**, control.
      2) Suction and Distributor: Seamless copper tube with brazed joints.
   i. Coating: Phenolic epoxy corrosion-protection coating after assembly.
9. Cooling-Coil Condensate Drain Pans:

a. Fabricated from galvanized steel **OR** stainless-steel, **as directed**, sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
b. Complying with requirements in ASHRAE 62.1-2004.
c. Drain Connections: At low point of pan with minimum <**Insert size**> threaded nipple.
d. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.

10. Hot-Water Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
    a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
    b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
    c. Tubes: Copper.
    d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
    e. Fins: Aluminum **OR** Copper, **as directed**.
    f. Fin and Tube Joint: Mechanical bond.
    g. Leak Test: Coils shall be leak tested with air under water.
    h. Coating: Phenolic epoxy corrosion-protection coating after assembly.
11. Nonfreeze Type, **as directed**, Steam Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
    a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
    b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
    c. Tubes: Copper.
    d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
    e. Fins: Aluminum **OR** Copper, **as directed**.
    f. Fin and Tube Joint: Mechanical bond.
    g. Leak Test: Coils shall be leak tested with air under water.
    h. Coating: Phenolic epoxy corrosion-protection coating after assembly.
12. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
    a. Casing Assembly: Slip-in **OR** Flanged, **as directed**, type with galvanized-steel frame.
    b. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
    c. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
       OR
       Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
    d. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
    e. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
    f. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection.
       1) Magnetic **OR** Mercury, **as directed**, contactor.
       2) Solid-state, stepless pulse controller.
       3) Toggle switches, one per step.
       4) Step controller.
       5) Time-delay relay.

6) Pilot lights, one per step.
7) Airflow proving switch.

13. Indirect-Fired Gas Furnaces:
    a. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
        1) AGA Approval: Furnace shall bear label of AGA.
    b. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
        1) Ignition: Electronically controlled electric spark with flame sensor.
        2) High-Altitude Model **OR** Kit, **as directed**: For Project at elevations more than 2000 feet (610 m) above sea level.
    c. Heat-Exchanger Drain Pan: Stainless steel.
    d. Venting: Gravity vented.
       OR
       Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
    e. Gas Control Valve: Single stage **OR** Two stage **OR** Electronic modulating, **as directed**.
    f. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff. Control devices and control sequence shall comply with requirements of FMG **OR** IRI, **as directed**.
    g. Access: Fabricate section to allow removal and replacement of furnace and to allow in-place access for service.
14. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
    a. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
    b. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
    c. Include fused **OR** nonfused, **as directed**, disconnect switches.
    d. Variable-speed controller to vary fan capacity from 100 to approximately 50 percent.
15. Accessories:
    a. Roof Curb: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**, with gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of 14 inches (350 mm) **OR** 24 inches (600 mm), **as directed**.
    b. Intake weather hood with 2-inch- (50-mm-) thick filters.
    c. Louvered intake weather hood with 2-inch- (50-mm-) thick filters in V-bank configuration.
    d. Exhaust weather hood with birdscreen.
    e. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade **OR** parallel-blade, **as directed**, arrangement with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
       OR
       Isolation Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
    f. Duct flanges.
    g. Rubber-in-shear isolators for ceiling-mounted units.
    h. Hinged access doors with quarter-turn latches.
    i. Drain pans for condensate removal complying with ASHRAE 62.1-2004, **as directed**.

j. Automatic, in-place, spray-wash system.
k. Weatherproofing for tilt-control system.

F. Controls
1. Time Clock: Solid-state, programmable, microprocessor-based unit for wall mounting **OR** mounting in outdoor NEMA 250, Type 3R enclosure, **as directed**, with up to eight on/off cycles per day and battery backup protection of program settings against power failure to energize unit.
2. Motion (Occupancy) Sensor: Passive infrared sensor for wall **OR** ceiling, **as directed**, mounting with adjustable time-off delay of up to 30 minutes to energize unit.
3. Carbon Monoxide Sensor: Adjustable control from 600 to 2000 ppm for wall **OR** duct, **as directed**, mounting with digital display and computer/building management system interface to energize unit.
4. Humidistat: Adjustable, wall-mounted instrument to energize unit when space relative humidity exceeds 50 percent.
5. Chilled-Water-Cooling-Coils Controls:
   a. For chilled-water cooling coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
   b. For chilled-water cooling coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
6. Refrigerant-Cooling-Coils Controls:
   a. For refrigerant cooling coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to control remote condensing unit to maintain temperature.
   b. For refrigerant cooling coils coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, controls remote condensing unit to maintain temperature.
   c. Cooling Capacity Control: On/off **OR** Multiple steps, **as directed**.
7. Hot-Water- and Steam-Coils Controls:
   a. For hot-water or steam coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
   b. For hot-water or steam coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
8. Electric-Coils Controls:
   a. For electric coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to control electric coil to maintain temperature.
   b. For electric coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to control electric coil to maintain temperature.
   c. Coil Controls: On/off **OR** Multiple steps **OR** Modulating SCR, **as directed**.
9. Indirect-Fired-Gas-Furnaces Controls:
   a. For indirect-fired gas furnaces with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct,

as directed, with sensor adjustment located in control panel to control gas furnace burner to maintain temperature.

b. For indirect-fired gas furnaces with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to control gas furnace burner to maintain temperature.

c. Burner Controls: On/off **OR** Multiple steps **OR** Modulating, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
3. Examine roughing-in for electrical services to verify actual locations of connections before installation.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
   a. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
   b. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
   c. Access doors and panels are specified in Division 15 Section "Duct Accessories".
2. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.
   a. Install heat exchanger with clearance space for heat-pipe coil removal.
   b. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Division 15 Section "Duct Accessories".
   c. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.
3. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
   a. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Division 15 Section "Duct Accessories".
4. Install gas-fired furnaces according to NFPA 54, "National Fuel Gas Code."
5. Install floor-mounted units on 4-inch- (100-mm-) high concrete base designed to withstand, without damage to equipment, seismic force required by code, **as directed**.
6. Equipment Mounting (for equipment supported on a concrete base on grade without vibration isolation devices): Install air-to-air energy recovery equipment on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Roof Curb: Install on roof structure or concrete base, level and secure, according to The NRCA "Roofing and Waterproofing Manual - Volume 4: Construction Details - Low-Slope Roofing,"

Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories". Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

8. Unit Support: Install unit level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure air-to-air energy recovery equipment to structural support with anchor bolts.
9. Install wind and seismic restraints according to manufacturers' written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
10. Suspended Units: Suspend and brace, **as directed**, units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
11. Install units with clearances for service and maintenance.
12. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
13. Pipe drains from units and drain pans to nearest floor drain; use ASTM B 88, Type L (ASTM B 88M, Type B), drawn-temper copper water tubing with soldered joints **OR** ASTM D 1785, Schedule 40 PVC pipe and solvent-welded fittings, **as directed**, same size as condensate drain connection.
    a. Requirements for Low-Emitting Materials:
        1) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
        2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Connections
1. Comply with requirements for piping specified in Division 15 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to unit to allow service and maintenance.
3. Connect piping to units mounted on vibration isolators with flexible connectors.
4. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
5. Chilled and Hot Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
6. Steam and Condensate Piping: Comply with applicable requirements in Division 15 Section "Steam And Condensate Piping". Install shutoff valve at steam coil connections, float and thermostatic trap, and union or flange at each coil return connection.
7. Refrigerant Piping: Comply with applicable requirements in Division 15 Section "Refrigerant Piping".
8. Gas Piping: Comply with requirements in Division 15 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make connection with AGA-approved flexible connectors.
9. Comply with requirements for ductwork specified in Division 15 Section "Metal Ducts".
10. Indirect-Fired Furnace Vent Connections: Comply with Division 15 Section "Breechings, Chimneys, And Stacks".
11. Electrical Connections: Comply with applicable requirements in Division 15.
    a. Install electrical devices furnished with units but not factory mounted.

D. Field Quality Control
1. Perform tests and inspections.

2. Tests and Inspections:
   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Adjust seals and purge.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   d. Set initial temperature and humidity set points.
   e. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 15734

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SECTION 15745 - RADIANT HEATING AND COOLING UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for radiant heating and cooling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Electric radiant heaters.
b. Prefabricated electric radiant heating panels.
c. Hydronic heating and cooling panels.

C. Definitions
1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.

D. Submittals
1. Product Data: Include rated capacities, specialties, and accessories for each product indicated.
2. Manufacturer Seismic Qualification Certification.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Electric Radiant Heaters
1. Quartz Lamp Heating Elements: Coiled tungsten-wire heating element enclosed in clear quartz tube.
2. Quartz Tube Heating Elements: Nickel-chromium-wire heating element enclosed in quartz tube.
3. Metal-Sheathed Heating Elements: Nickel-chromium-wire heating element embedded in magnesium oxide powder and enclosed in metal sheath. Comply with UL 1030.
4. Comply with UL 499 and UL 2021, **as directed**.
5. Enclosures: Aluminized **OR** Stainless **OR** Painted, **as directed,**-steel housing with anodized-aluminum reflector.
a. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** paint color as selected.
6. Unit Controls:
a. Line-voltage thermostat.
b. Enclosed contactor for remote thermostat.
c. Snow and ice detector with moisture sensor and integral temperature sensor.

B. Prefabricated Electric Radiant Heating Panels
1. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**. Comply with UL 2021.

a. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized-steel sheet back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized-steel sheet front panel with fused-on crystalline surface.
b. Heating Element: Powdered graphite sandwiched between sheets of electric insulation **OR** Insulated resistive wires, **as directed**.
c. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
d. Exposed-Side Panel Finish:
1) Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.
OR
Factory prime coated, ready for field painting.
OR
Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** paint color as selected.
e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** paint color as selected.

2. Wall Thermostat: Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low **OR** line, **as directed,**-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.
3. Capacities and Characteristics:
a. Nominal Panel Size: 24 by 24 inches (600 by 600 mm) **OR** 24 by 36 inches (600 by 900 mm) **OR** 24 by 48 inches (600 by 1200 mm) **OR** 24 by 60 inches (600 by 1500 mm), **as directed**.
b. Heating Capacity: 250 **OR** 375 **OR** 500 **OR** 570 **OR** 625 **OR** 750 **OR** 950, **as directed**, kW.

C. Hydronic Heating And Cooling, **as directed**, Panels
1. Description: Modular **OR** Linear, **as directed,** sheet metal panel with serpentine water piping, suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**.
a. Panels: Minimum 0.0336-inch- (0.86-mm-) thick, galvanized-steel **OR** 0.0396-inch- (1.0-mm-) thick, aluminum, **as directed,** sheet.
b. Backing Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed,** thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
c. Exposed-Side Panel Finish:
1) Apply silk-screened finish to match appearance of selected acoustical ceiling tiles.
OR
Factory prime coated, ready for field painting.
OR
Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** paint color as selected.
d. Factory Piping: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed,** copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** paint color as selected.
f. Accessories:
1) 5-inch (127-mm) **OR** 6-inch (152-mm) **OR** 8-inch (203-mm), **as directed,** panel with drape track recess.
2) 5-inch (127-mm) male bullnose panel.
3) 5-inch (127-mm) female bullnose panel.
4) 4-inch (102-mm) male corner panel.
5) 4-inch (102-mm) female corner panel.

6) Inside corner panel.
7) 1/2-inch (13-mm) filler panel.

2. Capacities and Characteristics:
   a. Nominal Panel Size: 24 by 24 inches (600 by 600 mm) **OR** 24 by 36 inches (600 by 900 mm) **OR** 24 by 48 inches (600 by 1200 mm) **OR** 24 by 60 inches (600 by 1500 mm), **as directed**.
   b. Piping Inlet and Outlet: NPS 1/2 (DN 15).

1.3 EXECUTION

A. Installation
1. Install radiant heating and cooling units level and plumb.
2. Suspend radiant heaters from structure.
3. Support for Radiant Heating and Cooling Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
   a. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
   b. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
   c. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.
   d. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
4. Verify locations of thermostats with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed,** above finished floor.
5. Piping installation requirements are specified in Division 15 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
6. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
7. Install piping adjacent to unit to allow service and maintenance.
8. Ground electric units according to Division 16 Section "Grounding And Bonding".
9. Connect wiring according to Division 16 Section "Conductors And Cables".

B. Field Quality Control
1. Testing: Perform the following field tests and inspections and prepare test reports:
   a. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.
2. Remove and replace malfunctioning units and retest as specified above.
3. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION 15745

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SECTION 15745a - RADIANT-HEATING ELECTRIC PANELS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for radiant-heating electric panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes prefabricated radiant-heating electric panels.

C. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: For electric heating panels. Include plans, sections, details, and attachments to other work.
   a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data: For electric heating panels to include in operation and maintenance manuals.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Prefabricated Radiant-Heating Electric Panels
1. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**. Comply with UL 2021.
   a. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized-steel sheet back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized-steel sheet front panel with fused-on crystalline surface.
   b. Heating Element:
      1) Powdered graphite sandwiched between sheets of electric insulation.
         OR
         Insulated resistive wires.
   c. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
   d. Exposed-Side Panel Finish:
      1) Apply silk-screened finish to match appearance of selected acoustical ceiling tiles.
      2) Factory prime coated, ready for field painting.
      3) Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
   e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.

2. Wall Thermostat: Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low **OR** line, **as directed**,-voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

1.3 EXECUTION

A. Installation
1. Install radiant-heating panels level and plumb.
2. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
   a. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
   b. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
   c. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.
   d. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
3. Verify locations of thermostats with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.

B. Connections
1. Ground equipment according to Division 16 Section "Grounding And Bonding".
2. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Testing: Perform the following field tests and inspections and prepare test reports:
   a. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   b. Test and adjust controls and safeties.
2. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 15745a

SECTION 15750 - AIR COILS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for air coils. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following types of air coils that are not an integral part of air-handling units:
   a. Hot-water.
   b. Chilled-water.
   c. Steam.
   d. Refrigerant.
   e. Electric.

C. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacity and pressure drop for each air coil.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance:
   a. Comply with ASHRAE 15 for refrigeration system safety.
   b. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
   c. Comply with applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

1.2 PRODUCTS

A. Water Coils
1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure/Temperature Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
3. Source Quality Control: Factory tested to 300 psig (2070 kPa).
4. Tubes: ASTM B 743 copper, minimum 0.020 inch (0.508 mm) **OR** 0.035 inch (0.889 mm) **OR** 0.049 inch (1.245 mm), **as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum 0.006 inch (0.152 mm) **OR** 0.010 inch (0.254 mm), **as directed**, thick.
6. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Steel with brazed joints, prime coated, **as directed**.
7. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

OR

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum 0.0625 inch (1.6 mm) thick for slip-in **OR** flanged, **as directed**, mounting.

8. Hot-Water Coil and Steam Coil, Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
   a. Coil Configuration: Horizontal **OR** Vertical, **as directed**, tubes.
   b. Dampers: Extruded-aluminum **OR** Galvanized-steel, **as directed**, blades with edge and end seals; full-length drive rod and mount for actuator in **OR** outside, **as directed**, the airstream.

B. Steam Coils
1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure/Temperature Ratings: 100 psig (690 kPa), 400 deg F (204 deg C).
3. Source Quality Control: Factory tested to 300 psig (2070 kPa).
4. Tubes: ASTM B 743 copper, minimum 0.025 inch (0.635 mm) **OR** 0.035 inch (0.889 mm) **OR** 0.049 inch (1.245 mm), **as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum 0.006 inch (0.152 mm) **OR** 0.010 inch (0.254 mm), **as directed**, thick.
6. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Steel with brazed joints, prime coated, **as directed**.
7. Tube Type: Single or distributing as indicated.
8. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.
   OR
   Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum 0.0625 inch (1.6 mm) thick for slip-in **OR** flanged, **as directed**, mounting.
9. Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
   a. Coil Configuration: Horizontal **OR** Vertical, **as directed**, tubes.
   b. Dampers: Extruded-aluminum **OR** Galvanized-steel, **as directed**, blades with edge and end seals; full-length drive rod and mount for actuator in **OR** outside, **as directed**, the airstream.

C. Refrigerant Coils
1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure Rating: 300 psig (2070 kPa).
3. Source Quality Control: Factory tested to 450 psig (3105 kPa).
4. Tubes: ASTM B 743 copper, minimum 0.020 inch (0.508 mm) **OR** 0.035 inch (0.889 mm) **OR** 0.049 inch (1.245 mm), **as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum 0.006 inch (0.152 mm) **OR** 0.010 inch (0.254 mm), **as directed**, thick.
6. Suction and Distributor Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper tube with brazed joints.
7. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.
   OR
   Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum 0.0625 inch (1.6 mm) thick for slip-in **OR** flanged, **as directed**, mounting.

D. Electric Coils
1. Coil Assembly: Comply with UL 1995.

2. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
   OR
   Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, and fastened to supporting brackets.
3. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
   a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
4. Frames: Galvanized-steel channel frame, minimum 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm) **OR** 0.079 inch (2.0 mm) **OR** 0.0625 inch (1.6 mm), **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.
5. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection. Include the following controls:
   a. Magnetic contactor.
   b. Mercury contactor.
   c. Toggle switches; one per step.
   d. Step controller.
   e. Time-delay relay.
   f. Pilot lights; one per step.
   g. Airflow proving switch.
6. Refer to Division 15 Section "Hvac Instrumentation And Controls" for thermostat.
   OR
   Thermostats: Wall-mounted thermostats, with temperature range from 50 to 90 deg F (10 to plus 32 deg C), and 2.5 deg F (1.4 deg C) throttling range.

1.3 EXECUTION

A. Installation
   1. Install coils level and plumb.
   2. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
   3. Install galvanized-steel **OR** stainless-steel, **as directed**, drain pan under each cooling coil.
      a. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1-2004, **as directed**.
      b. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
      c. Extend drain pan upstream and downstream from coil face.
      d. Extend drain pan under coil headers and exposed supply piping.
   4. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
   5. Straighten bent fins on air coils.
   6. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

B. Connections
   1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
   2. Install piping adjacent to coils to allow service and maintenance.
   3. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Division 15 Section "Hvac Instrumentation And Controls", and other piping specialties are specified in Division 15 Section "Hydronic Piping".
   4. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control

valves are specified in Division 15 Section "Hvac Instrumentation And Controls", and other piping specialties are specified in Division 15 Section "Steam And Condensate Piping".

5. Connect refrigerant piping according to Division 15 Section "Refrigerant Piping".
6. Ground equipment according to Division 16 Section "Grounding And Bonding".
7. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
   a. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
   b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 15750

SECTION 15751 - CONVECTION HEATING UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for convection heating units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Hydronic, Steam, and Electric baseboard radiators.
b. Hydronic, Steam, and Electric finned-tube radiators.
c. Hydronic, Steam, and Electric convectors.
d. Flat-pipe steel radiators.

C. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Electric Baseboard Radiators
1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
3. Enclosures: Minimum 0.0329-inch- (0.85-mm-) **OR** 0.0428-inch- (1.1-mm-), **as directed,** thick steel, removable front cover.
4. Rust-Resistant Enclosures: Minimum 0.040-inch- (1.0-mm-) **OR** 0.052-inch- (1.3-mm-), **as directed,** thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
a. Full-height back.
b. Full-length damper.
c. End panel.
d. Plastic end **OR** End, **as directed,** caps.
e. Inside and outside corners.
f. Joiner pieces to snap together.
g. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** color as selected.
h. Element Brackets: Primed and painted steel to support front panel and element.
5. Unit Controls: Integral line-voltage thermostat **OR** Integral electronic thermostat **OR** Remote line-voltage thermostat, **as directed**.

6. Accessories:
   a. Filler sections without a heating element matching the adjacent enclosure.
   b. Straight-blade-type receptacles complying with DSCC W-C-596G/GEN, NEMA WD 1, NEMA WD 6, and UL 498; in color selected.

B. Hot-Water Baseboard Radiators
1. Performance Ratings: Rate baseboard radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."
2. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on polypropylene element glides. One end of tube shall be belled.
   a. Tube Diameter: NPS 1/2 (DN 15) **OR** NPS 3/4 (DN 20) **OR** NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32), **as directed**.
   b. Fin Size: 2-1/2 by 2-1/2 inches (63 by 63 mm) **OR** 3 by 3 inches (76 by 76 mm), **as directed**.
   c. Fin Spacing: 40 per foot (131 per meter) **OR** 50 per foot (164 per meter) **OR** 58 per foot (190 per meter), **as directed**.
   d. Entering Air Temperature: 65 deg F (18 deg C).
   e. Average Water Temperature: 180 deg F (82 deg C).
   f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
   g. Entering Steam Pressure: 1 psig (6.9 kPa).
3. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on polypropylene element glides. Tube ends shall be threaded.
   a. Tube Diameter: NPS 1-1/4 (DN 32).
   b. Fin Size: 3 by 3 inches (76 by 76 mm).
   c. Fin Spacing: 52 per foot (171 per meter).
   d. Entering Air Temperature: 65 deg F (18 deg C).
   e. Average Water Temperature: 180 deg F (82 deg C).
   f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
   g. Entering Steam Pressure: 1 psig (6.9 kPa).
4. Enclosures: Minimum 0.0329-inch- (0.85-mm-) **OR** 0.0428-inch- (1.1-mm-), **as directed,** thick steel, removable front cover.
5. Rust-Resistant Enclosures: Minimum 0.040-inch- (1.0-mm-) **OR** 0.052-inch- (1.3-mm-), **as directed,** thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
   a. Full-height back.
   b. Full-length damper.
   c. End panel.
   d. End caps.
   e. Inside and outside corners.
   f. Valve access door.
   g. Joiner pieces to snap together.
   h. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** color as selected.
   i. Element Brackets: Primed and painted steel to support front panel and element.

C. Electric Finned-Tube Radiators
1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded into fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
3. Front Panel: Minimum 0.0428-inch- (1.1-mm-) **OR** 0.0528-inch- (1.35-mm-), **as directed,** thick steel.
4. Rust-Resistant Front Panel: Minimum 0.052-inch- (1.3-mm-) **OR** 0.064-inch- (1.6-mm-), **as directed,** thick ASTM A 653/A 653M, G60 galvanized steel.
5. Wall-Mounting Back Panel: Minimum 0.0329-inch- (0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.

6. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
7. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
8. Finish: Baked-enamel **OR**-epoxy, **as directed,** finish in manufacturer's standard **OR** custom, **as directed,** color as selected.
9. Damper: Knob-operated internal damper at enclosure outlet.
10. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
11. Enclosure Style: Sloped **OR** Flat, **as directed,** top.
    a. Front Inlet Grille: Punched louver; painted to match enclosure.
    b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
        1) Mill-finish aluminum.
        2) Anodized finish color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
        3) Painted to match enclosure.
    c. Top **OR** Front, **as directed,** Outlet Grille: Punched louver; painted to match enclosure.
    d. Top **OR** Front, **as directed,** Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
        1) Mill-finish aluminum.
        2) Anodized finish color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
        3) Painted to match enclosure.
12. Unit Controls: Integral line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C) **OR** low-voltage relay and control transformer for remote thermostat, **as directed**.
13. Accessories: Integral disconnect switch, filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

D. Hot-Water Finned-Tube Radiators
1. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
2. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One tube end shall be belled.
    a. Tube Diameter: NPS 3/4 (DN 20) **OR** NPS 1 (DN 25) **OR** NPS 1-1/4 (DN 32), **as directed**.
    b. Fin Size: 3 by 3 inches (76 by 76 mm) **OR** 4 by 4 inches (102 by 102 mm), **as directed**.
    c. Fin Spacing: 40 per foot (131 per meter) **OR** 50 per foot (164 per meter) **OR** 58 per foot (190 per meter), **as directed**.
    d. Entering Air Temperature: 65 deg F (18 deg C).
    e. Average Water Temperature: 180 deg F (82 deg C).
    f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
    g. Entering Steam Pressure: 1 psig (6.9 kPa).
3. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends shall be threaded.
    a. Tube Diameter: NPS 1-1/4 (DN 32).
    b. Fin Size: 4 by 4 inches (102 by 102 mm).
    c. Fin Spacing: 52 per foot (171 per meter).
    d. Entering Air Temperature: 65 deg F (18 deg C).
    e. Average Water Temperature: 180 deg F (82 deg C).
    f. Minimum Water Velocity: 1/2 fps (0.15 m/s).
    g. Entering Steam Pressure: 1 psig (6.9 kPa).
4. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
5. Front Panel: Minimum 0.0428-inch- (1.1-mm-) **OR** 0.0528-inch- (1.35-mm-), **as directed,** thick steel.
6. Rust-Resistant Front Panel: Minimum 0.052-inch- (1.3-mm-) **OR** 0.064-inch- (1.6-mm-), **as directed,** thick, ASTM A 653/A 653M, G60 galvanized steel.

7. Wall-Mounting Back Panel: Minimum 0.0329-inch- (0.85-mm-) thick steel, full height, with full-length channel support for front panel without exposed fasteners.
8. Floor-Mounting Pedestals: Conceal insulated piping at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.
9. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
10. Finish: Baked-enamel **OR**-epoxy, **as directed,** finish in manufacturer's standard **OR** custom, **as directed** color as selected.
11. Damper: Knob-operated internal damper at enclosure outlet.
12. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
13. Enclosure Style: Sloped **OR** Flat, **as directed,** top.
    a. Front Inlet Grille: Punched louver; painted to match enclosure.
    b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
        1) Mill-finish aluminum.
        2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
        3) Painted to match enclosure.
    c. Top **OR** Front, **as directed,** Outlet Grille: Punched louver; painted to match enclosure.
    d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
        1) Mill-finish aluminum.
        2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
        3) Painted to match enclosure.
14. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

E. Electric Convectors
1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded into fins, with high-temperature cutout and sensor running the full length of element. Element supports shall eliminate thermal expansion noise.
    a. Heat Output: 300 **OR** 500 **OR** 750 **OR** 1000 **OR** 1250 **OR** 1500 **OR** 1750 **OR** 2000 **OR** 2250 **OR** 2500, **as directed,** W.
3. Front and Top Panel: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed** thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
4. Wall-Mounting Back and End Panels: Minimum 0.0428-inch- (1.1-mm-) thick steel.
5. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
6. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.
7. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside of the back of the enclosure.
8. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** color as selected.
9. Damper: Knob-operated internal damper.
10. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.
11. Enclosure Style: Sloped **OR** Flat, **as directed,** top.
    a. Front Inlet Grille: Punched louver; painted to match enclosure.
    b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
        1) Mill-finish aluminum.

2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
3) Painted to match enclosure.

c. Top **OR** Front, **as directed,** Outlet Grille: Punched louver; painted to match enclosure.

d. Top **OR** Front, **as directed,** Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
1) Mill-finish aluminum.
2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
3) Painted to match enclosure.

12. Unit Controls: Integral line-voltage thermostat with minimum range of 60 to 90 deg F (15 to 32 deg C) **OR** low-voltage relay and control transformer for remote thermostat\, **as directed**.

13. Accessories: Integral disconnect switch, recessing flanges finished to match enclosure or overlapping front cover for fully recessed units, and rubber gaskets to seal cabinet at wall.

F. Hot-Water Or Steam Convectors

1. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig (690 kPa).
a. Entering Air Temperature: 65 deg F (18 deg C).
b. Average Water Temperature: 180 deg F (82 deg C).
c. Temperature Drop: 10 deg F (5.56 deg C) **OR** 20 deg F (11.1 deg C) **OR** 30 deg F (16.6 deg C), **as directed**.
d. Entering Steam Pressure: 1 psig (6.9 kPa).

2. Front and Top Panel: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed,** thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.

3. Wall-Mounting Back and End Panels: Minimum 0.0428-inch- (1.1-mm-) thick steel.

4. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch (914-mm) spacing. Pedestal-mounting back panel shall be solid panel matching front panel.

5. Support Brackets: Locate at maximum 36-inch (914-mm) spacing to support front panel and element.

6. Insulation: 1/2-inch- (13-mm-) thick, fibrous glass on inside of the back of the enclosure.

7. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed** color as selected.

8. Damper: Knob-operated internal damper.

9. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches (150 by 175 mm), integral with enclosure.

10. Enclosure Style: Sloped **OR** Flat, **as directed,** top.
a. Front Inlet Grille: Punched louver; painted to match enclosure.
b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
1) Mill-finish aluminum.
2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
3) Painted to match enclosure.
c. Top **OR** Front, **as directed,** Outlet Grille: Punched louver; painted to match enclosure.
d. Top **OR** Front, **as directed,** Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
1) Mill-finish aluminum.
2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed,** colors.
3) Painted to match enclosure.

G. Flat-Pipe Steel Radiators

1. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inches (2.76 mm). Include threaded piping and air vent connections.

a. Working Pressure 56 psig (386 kPa): 0.048 inch (1.22 mm).
b. Working Pressure 85 psig (585 kPa): 0.058 inch (1.47 mm).
c. Working Pressure 128 psig (881 kPa): 0.078 inch (1.98 mm).
d. Room Air Temperature: 65 deg F (18 deg C).
e. Average Water Temperature: 180 deg F (82 deg C).
f. Temperature Drop: 10 deg F (5.56 deg C) **OR** 20 deg F (11.1 deg C) **OR** 30 deg F (16.6 deg C), **as directed**.

2. Mounting: Wall brackets **OR** Floor pedestals, **as directed,** on maximum spacing of 36 inches (914 mm).
3. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed,** color as selected.
4. Accessories:
   a. Steel piping covers finished to match radiator finish.
   b. Flexible Expansion Compensation Hoses: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99.5 deg C).
      1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
      2) Minimum Diameter: Equal to connection size.

1.3 EXECUTION

A. Baseboard Radiator Installation
1. Install units level and plumb.
2. Install baseboard radiators according to Guide 2000 - Residential Hydronic Heating.
3. Install enclosure continuously around corners, using outside and inside corner fittings.
4. Join sections with splice plates and filler pieces to provide continuous enclosure.
5. Install access doors for access to valves.
6. Install enclosure continuously from wall to wall.
7. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
8. Install valves within reach of access door provided in enclosure.
9. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
10. Install piping within pedestals for freestanding units.

B. Finned-Tube Radiator Installation
1. Install units level and plumb.
2. Install finned-tube radiators according to Guide 2000 - Residential Hydronic Heating.
3. Install enclosure continuously around corners, using outside and inside corner fittings.
4. Join sections with splice plates and filler pieces to provide continuous enclosure.
5. Install access doors for access to valves.
6. Install enclosure continuously from wall to wall.
7. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
8. Install valves within reach of access door provided in enclosure.
9. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
10. Install piping within pedestals for freestanding units.

C. Convector Installation
1. Install units level and plumb.
2. Install valves within reach of access door provided in enclosure.
3. Install air-seal gasketing between wall and recessing flanges or front cover of fully recessed unit.
4. Install piping within pedestals for freestanding units.

D. Flat-Pipe Steel Radiator Installation
1. Install units level and plumb.

2. Install expansion compensation hoses.
3. Install piping covers.

E. Connections
1. Piping installation requirements are specified in Division 15 Section(s) "Hydronic Piping" OR "Steam And Condensate Piping", **as applicable.** Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect hot-water units and components to piping according to Division 15 Section "Hydronic Piping".
   a. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
3. Connect steam units and components to piping according to Division 15 Section "Steam And Condensate Piping".
   a. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
4. Install control valves as required by Division 15 Section "Hvac Instrumentation And Controls".
5. Install piping adjacent to convection heating units to allow service and maintenance.
6. Ground electric convection heating units according to Division 16 Section "Grounding And Bonding".
7. Connect wiring according to Division 16 Section "Conductors And Cables".

F. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   b. Operational Test: After electrical circuitry has been energized, start units to confirm proper convection heating unit operation.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

END OF SECTION 15751

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Task	Specification	Specification Description
15751	01352	No Specification Required
15752	01352	No Specification Required
15753	01352	No Specification Required
15753	15751	Convection Heating Units

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SECTION 15760 - UNIT HEATERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for unit heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Cabinet unit heaters with centrifugal fans and hot-water, steam, and electric-resistance heating coils.
b. Propeller unit heaters with hot-water, steam, and electric-resistance heating coils.
c. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

C. Definitions
1. BAS: Building automation system.
2. CWP: Cold working pressure.
3. PTFE: Polytetrafluoroethylene plastic.
4. TFE: Tetrafluoroethylene plastic.

D. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
2. LEED Submittal:
a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
a. Plans, elevations, sections, and details.
b. Location and size of each field connection.
c. Details of anchorages and attachments to structure and to supported equipment.
d. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
e. Location and arrangement of piping valves and specialties.
f. Location and arrangement of integral controls.
g. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.2 PRODUCTS

A. Cabinet Unit Heaters
1. Description: A factory-assembled and -tested unit complying with ARI 440.
   a. Comply with UL 2021.
2. Coil Section Insulation (for duct-liner-type, glass-fiber insulation): ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing **OR** erosion-resistant coating, **as directed**, to prevent erosion of glass fibers.
   a. Thickness: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
   b. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C) mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   d. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
   e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Coil Section Insulation (for flexible elastomeric insulation): Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
   a. Thickness: 3/8 inch (9 mm) **OR** 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
   b. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F (0.034 W/m x K at 24 deg C) mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
   d. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
   e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
4. Cabinet (for surface, semi-recessed, and fully recessed units): Steel with factory prime coating, ready for field painting **OR** baked-enamel finish with manufacturer's standard paint, in color selected by the Owner **OR** baked-enamel finish with manufacturer's custom paint, in color selected by the Owner, **as directed**.
   a. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed**, thick, galvanized, **as directed**, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
   b. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch- (1.35-mm-) **OR** 0.0677-inch- (1.7-mm-), **as directed**, thick, galvanized, **as directed**, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   c. Recessing Flanges (for units that are semirecessed or fully recessed in walls or ceilings): Steel, finished to match cabinet.
   d. Control Access Door: Key operated.
   e. Base (for surface, vertical, wall-mounting units): Minimum 0.0528-inch- (1.35-mm-) thick steel, finished to match cabinet, 4 inches (100 mm) **OR** 6 inches (150 mm), **as directed**, high with leveling bolts.
   f. Extended Piping Compartment: 8-inch- (200-mm-), **as directed**, wide piping end pocket.
   g. False Back (for vertical, wall-mounting units only): Minimum 0.0428-inch- (1.1-mm-) thick steel, finished to match cabinet.
   h. Outdoor-Air Wall Box (for vertical, wall-mounting units only): Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with anodized **OR** baked-enamel, **as directed**, finish in color selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.
      1) Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with manual **OR** electronic **OR** pneumatic, **as directed**, two-position actuators.

5. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   a. Washable Foam: 70 percent arrestance and 3 MERV.
   b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
   c. Pleated: 90 percent arrestance and 7 MERV.
6. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.
   OR
   Steam Coil: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (517 kPa).
   OR
   Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
7. Fan and Motor Board: Removable.
   a. Fan: Forward curved, high static, **as directed**, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
   b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
8. Factory, Hot-Water Piping Package: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.
   a. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve. Three-way valve packages shall include bypass line with manually adjustable balance device, **as directed**.
   b. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
      1) Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**,.
      2) Minimum Diameter: Equal to cabinet unit heater connection size.
   c. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
   d. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
   e. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig (2068-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning, piston-spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
   f. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) threaded pipe and full-port ball valve in strainer drain connection.
   g. Wrought-Copper Unions: ASME B16.22.
9. Control devices and operational sequences are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
10. Basic Unit Controls:
   a. Control voltage transformer.
   b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
      1) Heat-off switch.

2) Fan on-auto switch.
3) Manual fan speed switch (for use with multispeed motors).
4) Adjustable deadband.
5) Concealed **OR** Exposed, **as directed**, set point.
6) Concealed **OR** Exposed, **as directed**, indication.
7) Deg F (Deg C) indication.

c. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
d. Unoccupied period override push button.
e. Data entry and access port.
1) Input data includes room temperature, and occupied and unoccupied periods.
2) Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

11. DDC, **as directed**, Terminal Controller:
a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
b. Unoccupied Period Override: Two, **as directed**, hours.
c. Unit Supply-Air Fan Operations:
1) Occupied Periods: Fan runs continuously.
2) Unoccupied Periods: Fan cycles to maintain setback room temperature.
d. Heating Coil Operations:
1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
e. Outdoor-Air Damper Operation:
1) Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
2) Unoccupied Periods: Close damper.
f. Controller shall have volatile-memory backup.

12. BAS Interface Requirements:
a. Interface relay for scheduled operation.
b. Interface relay to provide indication of fault at central workstation.
c. Interface shall be BAC-net **OR** LonWorks, **as directed**, compatible for central BAS workstation and include the following functions:
1) Adjust set points.
2) Cabinet unit heater start, stop, and operating status.
3) Data inquiry, including outdoor-air damper position, **as directed**, supply-air and room-air temperature.
4) Occupied and unoccupied schedules.

13. Electrical Connection: Factory wire motors and controls for a single field connection.

B. Propeller Unit Heaters
1. Description: An assembly including casing, coil, fan, and motor in vertical **OR** horizontal **OR** vertical and horizontal, **as directed**, discharge configuration with adjustable discharge louvers.
2. Comply with UL 2021, for electric unit heaters.
3. Comply with UL 823, for explosion-proof electric unit heaters.
4. Cabinet: Removable panels for maintenance access to controls.
5. Cabinet Finish: Manufacturer's standard **OR** custom, **as directed**, baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
7. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

8. General Coil Requirements: Test and rate hot-water **OR** steam, **as directed**, propeller unit heater coils according to ASHRAE 33.
9. Hot-Water Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 350 psig (2413 kPa) underwater.
   OR
   Hot-Water Coil: Cupronickel tube, minimum 0.031-inch (0.78-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with manual air vent. Test for leaks to 600 psig (4137 kPa) underwater.
   OR
   Hot-Water Coil: Red brass tube, minimum 0.049-inch (1.24-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 260 psig (1793 kPa) and a maximum entering-water temperature of 390 deg F (199 deg C), with manual air vent. Test for leaks to 390 psig (2689 kPa) underwater.
   OR
   Hot-Water Coil: Steel tube, minimum 0.049-inch (1.24-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with manual air vent. Test for leaks to 600 psig (4137 kPa) underwater.
   OR
   Hot-Water Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with steel headers at top and bottom. Test for leaks to 600 psig (4137 kPa) underwater.
   OR
   Steam Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (520 kPa).
   OR
   Steam Coil: Red brass tube, minimum 0.049-inch (1.24-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (520 kPa).
   OR
   Steam Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 100 psig (690 kPa) **OR** 200 psig (1380 kPa), **as directed**, with steel headers at top and bottom.
10. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.
    a. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
    b. Wiring Terminations: Stainless-steel or corrosion-resistant material.
11. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
12. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
    a. Motor Type: Permanently lubricated, explosion proof **OR** multispeed **OR** variable speed, **as directed**.
13. Control Devices:
    a. Unit-mounted **OR** Wall-mounting, **as directed**, variable, **as directed**, fan-speed switch.
    b. Unit-mounted **OR** Wall-mounting, **as directed**, thermostat.

C. Wall And Ceiling Heaters
1. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
2. Cabinet:
   a. Front Panel: Stamped-steel louver **OR** Extruded-aluminum bar grille, **as directed**, with removable panels fastened with tamperproof fasteners.
   b. Finish: Baked enamel over baked-on primer with manufacturer's standard **OR** custom, **as directed**, color selected by the Owner, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
   c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.
4. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection, **as directed**.
5. Fan: Aluminum propeller directly connected to motor.
   a. Motor: Permanently lubricated, multispeed, **as directed**. Comply with requirements inDivision 15 Section "Common Motor Requirements For Hvac Equipment".
6. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit, **as directed**.
7. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch, **as directed**.

1.3 EXECUTION

A. Installation
1. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants".
2. Install cabinet unit heaters to comply with NFPA 90A.
3. Install propeller unit heaters level and plumb.
4. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints, **as directed**. Vibration isolators and seismic restraints, **as directed**, are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**. Hanger rods and attachments to structure are specified in Division 15 Section "Hangers And Supports For Hvac Piping And Equipment". Vibration hangers are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
7. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
4. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 15 Section "Duct Accessories".
5. Comply with safety requirements in UL 1995.

6. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 15 Section "Hydronic Piping".
7. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 15 Section "Steam And Condensate Piping".
8. Ground equipment according to Division 16 Section "Grounding And Bonding".
9. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.

D. Adjusting
1. Adjust initial temperature set points.
2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 15760

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Task	Specification	Specification Description
15760	01352	No Specification Required
15761	15675	Fan-Coil Units

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SECTION 15770 - PACKAGED TERMINAL AIR CONDITIONERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for packaged terminal air conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes packaged terminal air conditioners and their accessories and controls, in the following configurations:
   a. Through-the-wall and freestanding air conditioners.
   b. Cooling-only units.
   c. Heat-pump units.
   d. Cooling units with electric heat.
   e. Cooling units with hydronic heat.
   f. Cooling units with indirect-fired gas heat.

C. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For packaged terminal air conditioners. Include plans, elevations, sections, details for wall penetrations, seismic bracing, **as directed**, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
4. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.
5. Field quality-control reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged terminal air conditioners that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Substantial Completion, including components and labor.

b. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Substantial Completion, including only components and excluding labor.
c. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Units
1. Description: Factory-assembled and -tested, self-contained, packaged terminal air conditioner with room cabinet, electric refrigeration system, heating, **as directed**, and temperature controls; fully charged with refrigerant and filled with oil; with cord-connected **OR** hardwired, **as directed**, chassis.

B. Chassis
1. Cabinet: 0.052-inch- (1.32-mm-) thick steel with removable front panel with concealed latches.
a. Mounting: Wall with wall sleeve **OR** Floor with subbase, **as directed**.
b. Discharge Grille: Punched-louver discharge grille allowing four-way discharge-air pattern **OR** Extruded-aluminum discharge grille **OR** Reversible polycarbonate discharge grille allowing upward and horizontal airflow, **as directed**.
c. Louvers: Extruded aluminum with enamel finish **OR** Stamped aluminum with clear-anodized finish **OR** Stamped steel with enamel finish, **as directed**; white **OR** bronze **OR** brown **OR** beige, **as directed**, color.
d. Finish: Epoxy coating **OR** Baked enamel, **as directed**.
e. Access Door: Hinged door in top of cabinet for access to controls.
f. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
g. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
h. Subbase: Enameled steel with adjustable leveling feet and adjustable end plates, with factory-installed and -wired, fused disconnect switch and receptacle sized for unit, **as directed**.
i. Wall Sleeves: Galvanized steel with polyester finish **OR** Molded polymer **OR** Molded fiberglass-reinforced polyester, **as directed**.
2. Refrigeration System: Direct-expansion indoor coil with capillary restrictor; and hermetically sealed scroll compressor with vibration isolation and overload protection.
a. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins with capillary tube distributor on indoor coil, **as directed**.
b. Accumulator.
c. Constant-pressure expansion valve.
d. Reversing valve.
e. Charge: R-22 **OR** R-407C **OR** R-410A, **as directed**.
3. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with concealed manual **OR** electric, **as directed**, operator.
4. Filters: Washable polyurethane in molded plastic frame.
5. Condensate Drain: Drain pan to direct condensate to outdoor coil for re-evaporation **OR** and piping to direct condensate to building waste and vent piping, **as directed**.
a. Comply with ASHRAE 62.1-2004 for drain pan construction and connections.
6. Outdoor Fan: Forward curved, centrifugal **OR** Propeller, **as directed**, type with separate **OR** driven by indoor fan, **as directed**, motor.
a. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
1) Fan Motors: Permanently lubricated split capacitor.

2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.

C. Heating
1. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.
OR
Hot-Water Heating Coil: Seamless copper tubes mechanically expanded into aluminum fins with two-way modulating control valve and air vent.
OR
Gas Heat:
a. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.86/CSA 2.32, "Vented Gas-Fired Space Heating Appliances," and with NFPA 54.
b. Type of Gas: Natural **OR** Propane, **as directed**.
c. Heat Exchanger: Aluminized-steel **OR** Stainless steel, **as directed**.
d. Burner:
1) Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
2) Ignition: Electric pilot ignition with hot-surface igniter or electric spark ignition.
e. Gas-Burner Safety Controls:
1) Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
2) Flame Rollout Switch: Installed on burner box; prevents burner operation.
3) Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
f. Combustion-Air Inducer: Centrifugal fan prepurges heat exchanger and vents combustion products; thermally protected motor with sleeve bearings; pressure switch prevents operation if combustion-air inlet or flue outlet is blocked.
g. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; and terminals for connection to accessories.

D. Controls
1. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:
a. Low Ambient Lockout Control: Prevents cooling-cycle operation below 40 deg F (5 deg C) outdoor air temperature.
b. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above 40 deg F (5 deg C) and to supplemental heating below plus 25 deg F (minus 4 deg C).
c. Temperature-Limit Control: Prevents occupant from exceeding preset setback **OR** setup, **as directed**, temperature.
d. Building Automation System Interface: Allows remote on-off control with setback temperature control.
e. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on indoor **OR** outdoor, **as directed**, coil and reverses unit to melt frost.
2. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage adjustable thermostat with heat anticipator, heat-off-cool-auto **OR** heat-off-cool, **as directed**, switch, and on-auto, **as directed**, fan switch.
3. Outdoor Air: Manual **OR** Motorized, **as directed**, intake damper. Open intake when unit indoor air fan runs, **as directed**.

E. Source Quality Control

1. Sound-Power Level Ratings: Factory test to comply with ARI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."
2. Unit Performance Ratings: Factory test to comply with ARI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

1.3 EXECUTION

A. Installation
1. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
2. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants".
3. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

B. Connections
1. Comply with requirements for piping specified in Division 15 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements for piping specified in Division 15 Section "Facility Natural-gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to machine to allow service and maintenance.

C. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   b. After installing packaged terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Packaged terminal air conditioners will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

D. Startup Service
1. Perform startup service.
2. After installation, verify the following:
   a. Unit is level on base and is flashed in exterior wall.
   b. Unit casing has no visible damage.
   c. Compressor, air-cooled condenser coil, and fans have no visible damage.
   d. Labels are clearly visible.
   e. Controls are connected and operable.
   f. Shipping bolts, blocks, and tie-down straps are removed.
   g. Filters are installed and clean.
   h. Drain pan and drain line are installed correctly.
   i. Electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 15.
   j. Installation. Perform startup checks according to manufacturer's written instructions, including the following:
      1) Lubricate bearings on fan.
      2) Check fan-wheel rotation for correct direction without vibration and binding.
3. After startup service and performance test, change filters.

E. Adjusting
   1. Adjust initial temperature set points.
   2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

F. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain packaged terminal air conditioners.

END OF SECTION 15770

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SECTION 15770a - PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for packaged, outdoor, central-station air-handling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:
   a. Direct-expansion cooling.
   b. Heat-pump refrigeration components.
   c. Hot-gas reheat.
   d. Electric-heating coils.
   e. Gas furnace.
   f. Economizer outdoor- and return-air damper section.
   g. Integral, space temperature controls.
   h. Roof curbs.

C. Definitions
1. DDC: Direct-digital controls.
2. ECM: Electrically commutated motor.
3. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
4. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in RTUs. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.
5. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, outdoor, central-station air-handling units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.
6. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
7. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.
8. VVT: Variable-air volume and temperature.

D. Performance Requirements
1. Delegated Design: Design RTU supports to comply with wind and seismic, **as directed**, performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Wind-Restraint Performance:
   a. Basic Wind Speed: <**Insert value**>.
   b. Building Classification Category: I **OR** II **OR** III **OR** IV, **as directed**.
   c. Minimum 10 lb/sq. ft (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
3. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

E. Submittals
1. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   a. Wiring Diagrams: Power, signal, and control wiring.
4. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
   b. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
   c. Wind- and Seismic-Restraint Details, **as directed**: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
5. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Manufacturer Seismic Qualification Certification: Submit certification that RTUs, accessories, and components will withstand seismic forces defined in "Performance Requirements" Article and in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control test reports.
8. Operation and maintenance data.
9. Warranty: Special warranty specified in this Section.

F. Quality Assurance
1. ARI Compliance:
   a. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
   b. Comply with ARI 270 for testing and rating sound performance for RTUs.
2. ASHRAE Compliance:
   a. Comply with ASHRAE 15 for refrigeration system safety.
   b. Comply with ASHRAE 33 for methods of testing cooling and heating coils.

c. Comply with applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.
5. UL Compliance: Comply with UL 1995.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of RTUs that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Compressors: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Substantial Completion.
   b. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than five **OR** 10 **OR** 15 **OR** 20, **as directed**, years from date of Substantial Completion.
   c. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
   d. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.2 PRODUCTS

A. Casing

1. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
2. Exterior Casing Material: Galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
   a. Exterior Casing Thickness: 0.052 inch (1.3 mm) **OR** 0.0626 inch (1.6 mm) **OR** 0.079 inch (2.0 mm), **as directed**, thick.
3. Inner Casing Fabrication Requirements:
   a. Inside Casing: Galvanized steel, 0.034 inch (0.86 mm) **OR** 0.028 inch (0.7 mm), **as directed**, thick, perforated 40 percent free area, **as directed**.
4. Casing Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   a. Materials: ASTM C 1071, Type I.
   b. Thickness: 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**.
   c. Liner materials shall have air-stream surface coated with an erosion- and temperature-resistant coating or faced with a plain or coated fibrous mat or fabric.
   d. Liner Adhesive: Comply with ASTM C 916, Type I.
5. Condensate Drain Pans: Formed sections of galvanized-steel **OR** stainless-steel, **as directed**, sheet, a minimum of 2 inches (50 mm) deep, and complying with ASHRAE 62.1-2004, **as directed**.
   a. Double-Wall Construction: Fill space between walls with foam insulation and seal moisture tight.
   b. Drain Connections: Threaded nipple both sides of drain pan, **as directed**.
   c. Pan-Top Surface Coating: Corrosion-resistant compound for galvanized-steel drain pans.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

B. Fans

1. Direct-Driven Supply-Air Fans: Double width, forward curved **OR** backward inclined, **as directed**, centrifugal; with permanently lubricated, multispeed **OR** ECM, **as directed**, motor resiliently

mounted in the fan inlet. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

OR

Belt-Driven Supply-Air Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the casing. Aluminum or painted-steel wheels, and galvanized- or painted-steel fan scrolls.

2. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.
3. Relief-Air Fan: Propeller **OR** Forward curved **OR** Backward inclined, **as directed**, shaft mounted on permanently lubricated motor.
4. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fan-mounted frame and RTU-mounted frame are anchored to building structure.
5. Fan Motor: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

C. Coils

1. Supply-Air Refrigerant Coil:
   a. Aluminum-plate **OR** Copper-plate, **as directed**, fin and seamless internally grooved, **as directed**, copper tube in steel casing with equalizing-type vertical distributor.
   b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
   c. Coil Split: Interlaced.
   d. Baked phenolic **OR** Cathodic epoxy, **as directed**, coating.
   e. Condensate Drain Pan: Galvanized steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, formed with pitch and drain connections complying with ASHRAE 62.1-2004, **as directed**.
2. Outdoor-Air Refrigerant Coil:
   a. Aluminum-plate **OR** Copper-plate, **as directed**, fin and seamless internally grooved, **as directed**, copper tube in steel casing with equalizing-type vertical distributor.
   b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
   c. Baked phenolic **OR** Cathodic epoxy, **as directed**, coating.
3. Hot-Gas Reheat Refrigerant Coil:
   a. Aluminum-plate **OR** Copper-plate, **as directed**, fin and seamless internally grooved, **as directed**, copper tube in steel casing with equalizing-type vertical distributor.
   b. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
   c. Baked phenolic **OR** Cathodic epoxy, **as directed**, coating.
4. Electric-Resistance Heating:
   a. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
   b. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
   c. Overcurrent Protection: Manual-reset thermal cutouts, factory wired in each heater stage.
   d. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
      1) Magnetic **OR** Mercury, **as directed**, contactors.
      2) Step Controller: Pilot lights and override toggle switch for each step.
      3) SCR Controller: Pilot lights operate on load ratio, a minimum of five steps.
      4) Time-delay relay.

5) Airflow proving switch.

D. Refrigerant Circuit Components
1. Number of Refrigerant Circuits: One **OR** Two, **as directed**.
2. Compressor: Hermetic, reciprocating **OR** Semihermetic, reciprocating **OR** Hermetic, scroll, **as directed**, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater, **as directed**.
3. Refrigeration Specialties:
   a. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
   b. Expansion valve with replaceable thermostatic element.
   c. Refrigerant filter/dryer.
   d. Manual-reset high-pressure safety switch.
   e. Automatic-reset low-pressure safety switch.
   f. Minimum off-time relay.
   g. Automatic-reset compressor motor thermal overload.
   h. Brass service valves installed in compressor suction and liquid lines.
   i. Low-ambient kit high-pressure sensor.
   j. Hot-gas reheat solenoid valve with a replaceable magnetic coil.
   k. Hot-gas bypass solenoid valve with a replaceable magnetic coil.
   l. Four-way reversing valve with a replaceable magnetic coil, thermostatic expansion valves with bypass check valves, and a suction line accumulator.

E. Air Filtration
1. Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   a. Glass Fiber: Minimum 80 percent arrestance, and MERV 5.
   b. Pleated: Minimum 90 percent arrestance, and MERV 7.

F. Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54.
   a. CSA Approval: Designed and certified by and bearing label of CSA.
2. Burners: Stainless steel.
   a. Fuel: Natural **OR** Propane, **as directed**, gas.
   b. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
   c. High-Altitude Model **OR** Kit, **as directed**: For Project elevations more than 2000 feet (610 m) above sea level.
3. Heat-Exchanger and Drain Pan: Stainless steel.
4. Venting: Gravity vented with vertical extension, **as directed**.
   OR
   Power Vent: Integral, motorized centrifugal fan interlocked with gas valve with vertical extension, **as directed**.
5. Safety Controls:
   a. Gas Control Valve: Single stage **OR** Two stage **OR** Modulating, **as directed**.
   b. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

G. Dampers
1. Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with manual **OR** motorized, **as directed**, damper filter.
2. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
   a. Damper Motor: Modulating with adjustable minimum position.
   b. Relief-Air Damper: Gravity actuated or motorized, as required by ASHRAE/IESNA 90.1-2004, with bird screen and hood.

H. Electrical Power Connection
   1. Provide for single connection of power to unit with unit-mounted disconnect switch accessible from outside unit, **as directed**, and control-circuit transformer with built-in overcurrent protection.

I. Controls
   1. Control equipment and sequence of operation are specified in Division 15 Section "Hvac Instrumentation And Controls".
   2. Basic Unit Controls:
      a. Control-voltage transformer.
      b. Wall-mounted thermostat or sensor with the following features:
         1) Heat-cool-off switch.
         2) Fan on-auto switch.
         3) Fan-speed switch.
         4) Manual **OR** Automatic, **as directed**, changeover.
         5) Adjustable deadband.
         6) Concealed **OR** Exposed, **as directed**, set point.
         7) Concealed **OR** Exposed, **as directed**, indication.
         8) Degree F **OR** Degree C, **as directed**, indication.
         9) Unoccupied-period-override push button.
         10) Data entry and access port to input temperature and humidity, **as directed**, set points, occupied and unoccupied periods, and output room temperature and humidity, **as directed**, supply-air temperature, operating mode, and status.
      c. Wall-mounted humidistat or sensor with the following features:
         1) Concealed **OR** Exposed, **as directed**, set point.
         2) Concealed **OR** Exposed, **as directed**, indication.
      d. Remote Wall **OR** Unit, **as directed**,-Mounted Annunciator Panel for Each Unit:
         1) Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
         2) DDC controller or programmable timer and interface with HVAC instrumentation and control system.
         3) Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
   3. Electronic **OR** DDC, **as directed**, Controller:
      a. Controller shall have volatile-memory backup.
      b. Safety Control Operation:
         1) Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
         2) Firestats: Stop fan and close outdoor-air damper if air greater than 130 deg F (54 deg C) enters unit. Provide additional contacts for alarm interface to fire alarm control panel.
         3) Fire Alarm Control Panel Interface: Provide control interface to coordinate with operating sequence described in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed.**
         4) Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F (4 deg C).
         5) Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
      c. Scheduled Operation: Occupied and unoccupied periods on seven-day **OR** 365-day, **as directed**, clock with a minimum of two **OR** four, **as directed**, programmable periods per day.
      d. Unoccupied Period:
         1) Heating Setback: 10 deg F (5.6 deg C).
         2) Cooling Setback: System off.
         3) Override Operation: Two hours.

e. Supply Fan Operation:
   1) Occupied Periods: Run fan continuously.
   2) Unoccupied Periods: Cycle fan to maintain setback temperature.
f. Refrigerant Circuit Operation:
   1) Occupied Periods: Cycle or stage compressors, and operate hot-gas bypass, **as directed**, to match compressor output to cooling load to maintain room **OR** discharge, **as directed**, temperature and humidity, **as directed**. Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
   2) Unoccupied Periods: Compressors off **OR** Cycle compressors and condenser fans for heating to maintain setback temperature, **as directed**.
   3) Switch reversing valve for heating or cooling mode on air-to-air heat pump.
g. Hot-Gas Reheat-Coil Operation:
   1) Occupied Periods: Humidistat opens hot-gas valve to provide hot-gas reheat, and cycles compressor.
   2) Unoccupied Periods: Reheat not required.
h. Gas Furnace Operation:
   1) Occupied Periods: Cycle **OR** Stage **OR** Modulate, **as directed**, burner to maintain room **OR** discharge, **as directed**, temperature.
   2) Unoccupied Periods: Cycle burner to maintain setback temperature.
i. Electric-Heating-Coil Operation:
   1) Occupied Periods: Cycle **OR** Stage **OR** Modulate, **as directed**, coil to maintain room **OR** discharge, **as directed**, temperature.
   2) Unoccupied Periods: Energize coil to maintain setback temperature.
   3) Operate supplemental electric heating coil with compressor for heating with outdoor temperature below 25 deg F (minus 4 deg C).
j. Fixed Minimum Outdoor-Air Damper Operation:
   1) Occupied Periods: Open to 25 percent.
   2) Unoccupied Periods: Close the outdoor-air damper.
k. Economizer Outdoor-Air Damper Operation:
   1) Occupied Periods: Open to 10 **OR** 25, **as directed**, percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II. Controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C). Use outdoor-air temperature **OR** mixed-air and outdoor-air temperature **OR** outdoor-air enthalpy **OR** mixed-air temperature and select between outdoor-air and return-air enthalpy, **as directed**, to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper, **as directed**. During economizer cycle operation, lock out cooling.
   2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
   3) Outdoor-Airflow Monitor: Accuracy maximum plus or minus 5 percent within 15 and 100 percent of total outdoor air. Monitor microprocessor shall adjust for temperature, and output shall range from 2- to 10-V dc **OR** 4 to 20 mA, **as directed**.
l. Carbon Dioxide Sensor Operation:
   1) Occupied Periods: Reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 1000-ppm concentration.
   2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
m. VVT Relays:
   1) Provide heating- and cooling-mode changeover relays compatible with VVT terminal control system required in Division 15 Section(s) "Air Terminal Units" AND "Hvac Instrumentation And Controls".

4. Interface Requirements for HVAC Instrumentation and Control System:
   a. Interface relay for scheduled operation.
   b. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
   c. Provide BACnet **OR** LonWorks, **as directed**, compatible interface for central HVAC control workstation for the following:

1) Adjusting set points.
2) Monitoring supply fan start, stop, and operation.
3) Inquiring data to include outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
4) Monitoring occupied and unoccupied operations.
5) Monitoring constant and variable motor loads.
6) Monitoring variable-frequency drive operation.
7) Monitoring cooling load.
8) Monitoring economizer cycles.
9) Monitoring air-distribution static pressure and ventilation air volume.

J. Accessories
1. Electric heater with integral thermostat maintains minimum 50 deg F (10 deg C) temperature in gas burner compartment.
2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open, **as directed**.
3. Low-ambient kit using staged **OR** damper on **OR** variable-speed, **as directed**, condenser fans for operation down to 35 deg F (1.7 deg C).
4. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
5. Coil guards of painted, galvanized-steel wire.
6. Hail guards of galvanized steel, painted to match casing.
7. Concentric diffuser with white louvers and polished aluminum return grilles, insulated diffuser box with mounting flanges, and interior transition.

K. Roof Curbs
1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
OR
Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
   a. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
      1) Materials: ASTM C 1071, Type I or II.
      2) Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**.
   b. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
      1) Liner Adhesive: Comply with ASTM C 916, Type I.
      2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
      3) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
      4) Liner Adhesive: Comply with ASTM C 916, Type I.
2. Curb Height: 14 inches (355 mm) **OR** 24 inches (610 mm) **OR** 36 inches (910 mm), **as directed**.
3. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for wind-load requirements.

1.3 EXECUTION

A. Installation

1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   a. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger than supported equipment and minimum 6 inches (150 mm) above finished ground elevation.
   b. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   c. Install anchor bolts to elevations required for proper attachment to supported equipment.
   d. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   e. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
2. Equipment Mounting: Install RTUs on concrete base using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.

   OR

   Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories". Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
3. Unit Support: Install unit level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure RTUs to structural support with anchor bolts.
4. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

B. Connections

1. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
2. Install piping adjacent to RTUs to allow service and maintenance.
   a. Gas Piping: Comply with applicable requirements in Division 15 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
3. Duct installation requirements are specified in other Division 15. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   a. Install ducts to termination at top of roof curb.
   b. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
   c. Connect supply ducts to RTUs with flexible duct connectors specified in Division 15 Section "Duct Accessories".
   d. Install return-air duct continuously through roof structure.
   e. Install normal-weight, 3000-psi (20.7-MPa), compressive strength (28-day) concrete mix inside roof curb, 4 inches (100 mm) thick. Concrete, formwork, and reinforcement are specified in Division 02.

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:

a. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
b. Inspect for and remove shipping bolts, blocks, and tie-down straps.
c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
2. Complete installation and startup checks according to manufacturer's written instructions and do the following:
   a. Inspect for visible damage to unit casing.
   b. Inspect for visible damage to furnace combustion chamber.
   c. Inspect for visible damage to compressor, coils, and fans.
   d. Inspect internal insulation.
   e. Verify that labels are clearly visible.
   f. Verify that clearances have been provided for servicing.
   g. Verify that controls are connected and operable.
   h. Verify that filters are installed.
   i. Clean condenser coil and inspect for construction debris.
   j. Clean furnace flue and inspect for construction debris.
   k. Connect and purge gas line.
   l. Remove packing from vibration isolators.
   m. Inspect operation of barometric relief dampers.
   n. Verify lubrication on fan and motor bearings.
   o. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   p. Adjust fan belts to proper alignment and tension.
   q. Start unit according to manufacturer's written instructions.
      1) Start refrigeration system.
      2) Do not operate below recommended low-ambient temperature.
      3) Complete startup sheets and attach copy with Contractor's startup report.
   r. Inspect and record performance of interlocks and protective devices; verify sequences.
   s. Operate unit for an initial period as recommended or required by manufacturer.
   t. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
      1) Measure gas pressure on manifold.
      2) Inspect operation of power vents.
      3) Measure combustion-air temperature at inlet to combustion chamber.
      4) Measure flue-gas temperature at furnace discharge.
      5) Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
      6) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
   u. Calibrate thermostats.
   v. Adjust and inspect high-temperature limits.
   w. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
   x. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F (8 deg C) above return-air temperature:
      1) Coil leaving-air, dry- and wet-bulb temperatures.
      2) Coil entering-air, dry- and wet-bulb temperatures.
      3) Outdoor-air, dry-bulb temperature.
      4) Outdoor-air-coil, discharge-air, dry-bulb temperature.

y. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.

z. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
   1) Supply-air volume.
   2) Return-air volume.
   3) Relief-air volume.
   4) Outdoor-air intake volume.

aa. Simulate maximum cooling demand and inspect the following:
   1) Compressor refrigerant suction and hot-gas pressures.
   2) Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

bb. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
   1) High-temperature limit on gas-fired heat exchanger.
   2) Low-temperature safety operation.
   3) Filter high-pressure differential alarm.
   4) Economizer to minimum outdoor-air changeover.
   5) Relief-air fan operation.
   6) Smoke and firestat alarms.

cc. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

E. Cleaning And Adjusting
   1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.
   2. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

F. Demonstration

G. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION 15770a

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SECTION 15770b - ROOFTOP REPLACEMENT AIR UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for rooftop replacement-air units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes cooling-only and cooling and heating rooftop replacement-air units.

C. Definitions
1. DDC: Direct-digital controls.

D. Submittals
1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings: Include details of installation and wiring diagrams.
3. Coordination Drawings: Rooftop replacement-air units to roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   a. Size and location of rooftop replacement-air unit mounting rails and anchor points and methods for anchoring units to roof curb.
   b. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.
4. Startup service reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.
7. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
   b. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Cabinet
1. Construction: Single **OR** Double, **as directed**, wall.
2. Exterior Casing: Galvanized steel with baked-enamel paint finish and **OR** Stainless steel, **as directed**, with lifting lugs and knockouts for electrical and piping connections.
3. Interior Casing: Galvanized-steel **OR** Stainless steel, **as directed**.
4. Base Rails: Galvanized-steel **OR** Stainless-steel, **as directed**, rails for mounting on roof curb.
5. Service Doors: Hinged access doors with neoprene gaskets.
6. Internal Insulation: Fibrous-glass duct lining complying with ASTM C 1071, Type II.
   a. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
   b. Insulation Adhesive: Comply with ASTM C 916, Type I.
   c. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.
7. Condensate Drain Pans: Formed sections of galvanized-steel **OR** stainless-steel, **as directed**, sheet designed for self-drainage. Fabricate pans and drain connection to comply with ASHRAE 62.1-2004.
8. Roof Curb: Full-perimeter curb of sheet metal, minimum 8 inches (200 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm), **as directed**, high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
9. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

B. Supply-Air Fan
1. Fan: Forward-curved centrifugal; statically and dynamically balanced, galvanized **OR** coated, **as directed**, steel, mounted on solid-steel shaft with self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated L_{50} for 200,000 hours and having external grease fittings, **as directed**.
2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single-speed **OR** two-speed, **as directed**, motor.
3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4 service factor.
4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, **as directed**, elastomeric **OR** spring, **as directed**, isolators.

C. Refrigeration System
1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
2. Compressors: Reciprocating **OR** Scroll, **as directed**, compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater, **as directed**.
3. Minimum Efficiency: As defined by ASHRAE/IESNA 90.1-2004, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
4. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
5. Refrigeration System Specialties:
   a. Expansion valve with replaceable thermostatic element.
   b. Refrigerant dryer.
   c. High-pressure switch.
   d. Low-pressure switch.
   e. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
   f. Brass service valves installed in discharge and liquid lines.
   g. Operating charge of refrigerant.

6. Capacity Control: Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.
   OR
   Capacity Control: Patented, Rawal APR control with zero to 100 percent modulating capacity control using hot-gas bypass. Evaporator coil shall be continuously active for dehumidification.
   OR
   Capacity Control: Single compressor with evaporator and condenser coil within the refrigerant section to provide initial precooling and reheat for humidity control.
   OR
   Capacity Control: Heat-pipe heat exchanger shall wrap around the evaporator coil to precool the air entering the evaporator coil, and reheat the air leaving the evaporator coil to control humidity.
7. Refrigerant Coils: Evaporator and condenser **OR** Evaporator, condenser, and reheat condenser, **as directed**, coils shall be designed, tested, fabricated, and rated according to ARI 410 and ASHRAE 33. Coils shall be leak tested under water with air at 315 psig (2170 kPa).
   a. Capacity Reduction: Circuit coils for face **OR** row **OR** interleaved, **as directed**, control.
   b. Tubes: Copper.
   c. Fins: Aluminum **OR** Copper, **as directed**, with minimum fin spacing of 0.071 inch (1.81 mm), **as directed**.
   d. Fin and Tube Joint: Mechanical bond.
   e. Suction and Distributor: Seamless copper tube with brazed joints.
   f. Coating: Phenolic epoxy corrosion-protection coating on both coils.
   g. Source Quality Control: Test to 450 psig (3105 kPa), and to 300 psig (2070 kPa) underwater.
8. Condenser Fan: Propeller type, directly driven by motor.
9. Safety Controls:
   a. Compressor motor and outside-coil fan motor low ambient lockout.
   b. Overcurrent protection for compressor motor and outside-coil fan motors.

D. Direct-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code"; ANSI Z83.4, "Non-Recirculating Direct Gas-Fired Industrial Air Heaters"; and ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters," for direct-fired gas furnace.
2. Burners: Cast-iron burner with stainless-steel mixing plates.
   a. Rated for a maximum turndown ratio of 30:1.
   b. Fuel: Natural **OR** Propane, **as directed**, gas.
3. Safety Controls:
   a. Gas manifold safety switches and controls shall comply with ANSI standards and FMG **OR** and IRI, **as directed**.
   b. Pilot: Intermittent spark igniter.
   c. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
   d. External gas-pressure regulator shall regulate pressure to not more than 0.5 psig (3.4 kPa).
   e. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
   f. Manual-Reset, High-Limit Switch: Stops burner and closes main gas valve if high-limit temperature is exceeded.
   g. Gas Train: Redundant, main gas valves, electric pilot valve, main and pilot gas-pressure regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas-pressure switches **OR** to comply with FMG requirements **OR** to comply with IRI requirements, **as directed**.

E. Indirect-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
   a. AGA Approval: Designed and certified by and bearing label of AGA.

2. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
   a. Minimum AFUE: <**Insert value**> percent.
      OR
      Minimum Thermal Efficiency: <**Insert value**> percent.
      OR
      Minimum Combustion Efficiency: <**Insert value**> percent.
   b. Fuel: Natural **OR** Propane, **as directed**, gas.
   c. Ignition: Electronically controlled electric spark with flame sensor.
   d. High-Altitude Model **OR** Kit, **as directed**: For Project elevations more than 2000 feet (610 m) above sea level.
3. Heat-Exchanger Drain Pan: Stainless steel.
4. Venting: Gravity vented.
   OR
   Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
5. Safety Controls:
   a. Gas Control Valve: Single stage **OR** Two stage **OR** Electronic modulating, **as directed**.
   b. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

F. Electric-Resistance Heating
1. Electric-Resistance Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
   OR
   Electric-Resistance Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
   a. Heating Capacity: Low density 35 W per sq. in. (54 kW per sq. m), factory wired for single-point wiring connection; with time delay for element staging, and overcurrent and overheat protective devices.
   b. Safety Controls:
      1) Blower-motor interlock, air-pressure switch.
      2) Quiet mercury contactors.
      3) Time delay between steps.
      4) Integral, nonfused power disconnect switch.

G. Heating Coils
1. Hot-Water Coils: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil fabricated and tested according to ARI 410 with aluminum fins and seamless copper tube in galvanized-steel **OR** stainless-steel, **as directed**, casing.
   a. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
   b. Control valves are specified in Division 15 Section "Hvac Instrumentation And Controls".
2. Steam Coils: Distributing coil fabricated and tested according to ARI 410, with threaded steam supply and condensate connections. Nonfreeze type having aluminum-plate fin and seamless copper double tube in galvanized-steel casing, pitched for proper drainage; tested to 150 psig (1035 kPa) and leak tested to 100 psig (690 kPa) with air under water.
   a. Control valves are specified in Division 15 Section "Hvac Instrumentation And Controls".

H. Cooling Coils
1. Chilled-Water Coils: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil fabricated and tested according to ARI 410 with aluminum fins and seamless copper tube in galvanized-steel **OR** stainless-steel, **as directed**, casing.

a. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
b. Control valves are specified in Division 15 Section "Hvac Instrumentation And Controls".

I. Outdoor-Air Intake And Dampers
1. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of 2000 fpm (10 m/s) through damper and pressure differential of 4-inch wg (1000 Pa).
2. Damper Operators: Electric.
3. Mixing Boxes: Parallel-blade, galvanized-steel dampers mechanically fastened to steel operating rod inside cabinet. Connect operating rods with common interconnecting linkages so dampers operate simultaneously.
4. Outdoor-Air Intake Hoods: Galvanized-steel **OR** Stainless steel, **as directed**, with bird screen complying with ASHRAE 62.1-2004 and finish to match cabinet.

J. Filters
1. Comply with NFPA 90A.
2. Cleanable Filters: 2-inch- (50-mm-) thick, cleanable metal mesh.
OR
Disposable Panel Filters: 2-inch- (50-mm-) thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1, **as directed**.
a. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
b. Frame: Galvanized steel.

K. Controls
1. Factory-wire connection for controls' power supply.
2. Control devices, including sensors, transmitters, relays, switches, thermostats, humidistats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.
3. Unit Controls: Solid-state control board and components with field-adjustable control parameters.
4. Supply-Fan Control: Units shall be electrically interlocked with corresponding exhaust fans, to operate continuously when exhaust fans are running. Time clock shall switch operation from occupied to unoccupied. Night setback thermostat shall cycle fan during unoccupied periods to maintain space temperature.
a. Timer: Seven-day electronic clock.
b. Electrically interlock kitchen hood fire-extinguishing system to de-energize replacement-air unit when fire-extinguishing system discharges.
5. Remote **OR** Unit, **as directed**,-Mounted Status Panel:
a. Cooling/Off/Heating Controls: Control operational mode.
b. Damper Position: Indicates position of outdoor-air dampers in terms of percentage of outdoor air.
c. Status Lights:
1) Filter dirty.
2) Fan operating.
3) Cooling operating.
4) Heating operating.
6. Refrigeration System Controls:
a. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than 28 Btu/lb (65 kJ/kg) of dry air or outdoor-air temperature is less than 60 deg F (15 deg C).
b. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than 60 deg F (15 deg C).
c. Wall-mounting, relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 60 percent.

7. Heating Controls:
   a. Factory-mounted sensor in supply-fan outlet **OR** Remote-mounting sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel modulates gas furnace burner to maintain space temperature.
   b. Wall-mounting, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, that modulates gas furnace burner to maintain space temperature.
   c. Remote Setback Thermostat: Adjustable room thermostat selected by timer, set at 50 deg F (10 deg C); cycles supply fan and gas furnace burner to maintain space temperature.
   d. Staged Burner Control: Two **OR** Four, **as directed**, steps of control.
      OR
      Electromechanical or Electronic Burner Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual furnace units.
8. Electric-Resistance Heating Controls: Wall-mounting thermostat controls SCR **OR** sequences stages, **as directed**.
9. Damper Controls:
   a. Wall-mounting pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space served by rooftop replacement-air unit at minimum 0.05-inch wg (12.4 Pa).
   b. When exhaust fans stop, set outdoor- and return-air damper to 75 **OR** 50 **OR** 25, **as directed**, percent outdoor air. When exhaust fans start, close return-air damper and fully open outdoor-air damper.
10. Integral Smoke Alarm: Smoke detector installed in supply and return air.
11. DDC Temperature Control: Stand-alone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with temperature-control system specified in Division 15 Section "Hvac Instrumentation And Controls". Links shall include the following:
    a. Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
    b. Hardware interface or additional sensors for the following:
       1) Room temperature.
       2) Discharge air temperature.
       3) Refrigeration system operating.
       4) Furnace operating.

L. Motors
1. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation
1. Install roof curb on roof structure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install and secure rooftop replacement-air units on curbs and coordinate roof penetrations and flashing with roof construction.
   OR
   Install restrained vibration isolation roof-curb rails on roof structure according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install and secure rooftop replacement-air units on rails and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

2. Install wall- and duct-mounting sensors, thermostats, and humidistats furnished by manufacturers for field installation. Install control wiring and make final connections to control devices and unit control panel.
3. Install 3000-psi (20.7-MPa), compressive strength (28-day) concrete base inside roof curb, 4 inches (100 mm) thick. Concrete and reinforcement are specified in Division 02.

B. Connections
1. Piping installation requirements are specified in other Division 15-. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
   a. Gas Burner Connections: Comply with requirements in Division 15 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to burner, full size of gas train inlet, and connect with union, pressure regulator, **as directed**, and shutoff valve with sufficient clearance for burner removal and service.
   b. Water Coil Connections: Comply with requirements in Division 15 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
   c. Steam Coil Connections: Comply with requirements in Division 15 Section "Steam And Condensate Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.
3. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to rooftop replacement-air units with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories".
4. Electrical Connections: Comply with requirements in Division 15 for power wiring, switches, and motor controls.
5. Ground equipment according to Division 16 Section "Grounding And Bonding".

C. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Inspect for visible damage to furnace combustion chamber.
   b. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
   c. Inspect casing insulation for integrity, moisture content, and adhesion.
   d. Verify that clearances have been provided for servicing.
   e. Verify that controls are connected and operable.
   f. Verify that filters are installed.
   g. Clean outside coil and inspect for construction debris.
   h. Clean furnace flue and inspect for construction debris.
   i. Inspect operation of power vents.
   j. Purge gas line.
   k. Inspect and adjust vibration isolators and seismic restraints.
   l. Verify bearing lubrication.
   m. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
   n. Adjust fan belts to proper alignment and tension.
   o. Start unit.
   p. Start refrigeration system when outdoor-air temperature is within normal operating limits.
   q. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
   r. Operate unit for run-in period.
   s. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
      1) Measure gas pressure at manifold.

2) Measure combustion-air temperature at inlet to combustion chamber.
3) Measure flue-gas temperature at furnace discharge.
4) Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
5) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

t. Calibrate thermostats.
u. Adjust and inspect high-temperature limits.
v. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers, **as directed**.
w. Start refrigeration system and measure and record the following:
1) Coil leaving-air, dry- and wet-bulb temperatures.
2) Coil entering-air, dry- and wet-bulb temperatures.
3) Outdoor-air, dry-bulb temperature.
4) Outdoor-air-coil, discharge-air, dry-bulb temperature.
x. Verify operational sequence of controls.
y. Measure and record the following airflows. Plot fan volumes on fan curve.
1) Supply-air volume.
2) Return-air volume.
3) Outdoor-air intake volume.
z. Simulate maximum cooling demand and inspect the following:
1) Compressor refrigerant suction and hot-gas pressures.
2) Short circuiting of air through outside coil or from outside coil to outdoor-air intake.
aa. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
1) High-limit heat exchanger.
2) Alarms.

3. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
4. Remove and replace components that do not pass tests and inspections and retest as specified above.
5. Prepare written report of the results of startup services.

D. Adjusting
1. Adjust initial temperature and humidity set points.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop replacement-air units.

END OF SECTION 15770b

SECTION 15770c - SELF-CONTAINED AIR-CONDITIONERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for self-contained air-conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged air-conditioning units with refrigerant compressors and controls, intended for indoor installations, with water-cooled, externally mounted air-cooled, and integral air-cooled condensers.

C. Submittals
1. Product Data: For each unit indicated.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

E. Warranty
1. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of self-contained air-conditioners that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. Packaged Units
1. Description: Self-contained, factory-assembled and -wired unit; consisting of cabinet, compressor, evaporator fan, evaporator coil, air filters, and controls; and fully charged with refrigerant and oil.
   a. Condenser: Water-cooled **OR** Externally mounted air-cooled **OR** Integral air-cooled, **as directed**, condenser.

2. Disconnect Switch: Factory mounted in control panel **OR** on equipment, **as directed**.

B. Cabinet
1. Frame and Panels: Structural-steel frame with galvanized-steel panels with baked-enamel finish in color selected by the Owner, and with access doors or panels.
2. Insulation: Minimum 1/2-inch- (13-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, acoustic duct liner on cabinet interior and control panel.
3. Drain Pan: Galvanized steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, complying with ASHRAE 62.1-2004, **as directed**.
4. Isolation: Spring isolators for mounting under base of unit, with minimum static deflection of 1 inch (25 mm).
5. Discharge Plenum: Cabinet extension with directional louvers.
   OR
   Discharge Plenum: Cabinet extension with duct openings for air discharge and lined with a minimum of 2-inch- (50-mm-) thick duct liner.
   OR
   Corrosion-Resistant Treatment: Phenolic coating on unit interior and exterior.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

C. Evaporator Fan
1. Material: Galvanized steel.
2. Configuration: Double-width, double-inlet, forward-curved **OR** airfoil, **as directed**, centrifugal fan; statically and dynamically balanced.
3. Drive: Belt, with fan mounted on permanently lubricated bearings **OR** Direct, with fan and motor resiliently mounted, **as directed**.
4. Fan Sheaves: Cast-iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed.
5. Motor Sheave: Variable and adjustable pitch selected so required rpm are obtained when set at midposition.
6. Rating: As recommended by the manufacturer or a minimum of one and one-half times nameplate rating of motor.
7. Bearings: Grease lubricated with grease lines extended to exterior of unit.
8. Variable Air Volume: Inlet guide vanes with electric modulating actuator; linkage; and adjustable, static-pressure controller responding to a static-pressure sensor.
   OR
   Variable Air Volume: Variable-frequency motor controller.

D. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
1. Motors (for units 15 tons (50 kW) and smaller): Multispeed, PSC type.
2. Motors: Open-dripproof **OR** Totally enclosed fan-cooled, **as directed**, type.
   a. Special Motor Features: Premium efficiency, as defined in Division 15 Section "Common Motor Requirements For Hvac Equipment".
3. Isolation (for units larger than 15 tons (50 kW)): Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of 1 inch (25 mm).

E. Compressor
1. Description: Hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.
2. Compressor Type: Reciprocating **OR** Scroll, **as directed**.

F. Evaporator Coil
1. Direct-Expansion Coil: Seamless copper tubes expanded into aluminum fins.
   a. Corrosion-Resistant Treatment, **as directed**: Phenolic coating applied with multiple dips and baked.

2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, **as directed**, filter-dryer, sight glass, high-pressure relief valve, **as directed**, and charging valves.

G. Water-Cooled Condenser
1. Description: Copper tubes in steel shell with removable heads, for 400-psig (2760-kPa) waterside working pressure.
   a. ASME Compliance: Fabricate and label water-cooled condensers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
   b. Water-Flow Switch: Indicates flow.

H. Remote Air-Cooled Condenser
1. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and operating controls; suitable for roof mounting.
   a. Condenser Coil: Aluminum-fin copper tube with integral subcooler; leak tested to 450 psig (3110 kPa).
   b. Condenser Fans: Direct-drive propeller type.
   c. Fan Motors: Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   d. Refrigerant Line Kits: Annealed-copper suction and liquid lines that are factory cleaned, dried, pressurized, and sealed; insulated suction line; flared fittings at evaporator end, no fitting at condenser end; and service valves for both suction and liquid lines.
   e. Terminate suction and liquid refrigerant piping with service valves within unit.
   f. Low Ambient Control: Cycles fans to permit operation down to 45 deg F (7 deg C).
      OR
      Low Ambient Control: Cycles fans and modulates condenser fan damper assembly to permit operation down to 0 deg F (minus 18 deg C).
   g. Coil Guard: Painted galvanized steel with louvered grilles.
   h. Corrosion-Resistant Treatment: Phenolic coating applied in multiple dips and baked.

I. Integral Air-Cooled Condenser For Units 15 Tons (50 kW) And Smaller
1. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and cabinet.
   a. Condenser Coil: Aluminum-fin copper tube with integral subcooler; leak tested to 425 psig (2930 kPa).
   b. Condenser Fan: Direct-drive propeller type with permanently lubricated motor with built-in thermal-overload protection.
   c. Low Ambient Control: Cycles fans to permit operation down to 0 deg F (minus 18 deg C).

J. Refrigeration System
1. Description: Factory assembled and tested, and charged with CFC-free refrigerant; consisting of piping and accessories connecting compressor, evaporator coil, and condenser coil, and including the following:
   a. Four-way reversing valve and suction-line accumulator.
   b. Expansion valve with replaceable thermostatic element.
   c. Refrigerant dryer.
   d. High-pressure switch.
   e. Low-pressure switch.
   f. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
   g. Low ambient switch.
   h. Brass service valves installed in discharge and liquid lines.
2. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.

K. Heating Coil

1. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm); leak tested to 300 psig (2070 kPa) underwater; and having a two-position control valve.
2. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.

L. Air Filters
1. Permanent Filters: 1-inch- (25-mm-) thick, cleanable panel filters.
OR
Disposable Filters: 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, glass-fiber, flat **OR** pleated, **as directed**, panel filters.
OR
Extended-Surface, Disposable Panel Filters: 2-inch- (50-mm-) **OR** 4-inch- (100-mm-), **as directed**, thick, dry, filters with fibrous media material formed into deep-V-shaped pleats and held by self-supporting wire grid holding frames, with nonflammable cardboard media and media-grid frame.
   a. Efficiency: ASHRAE 52.2 MERV rating of 6 or higher.
2. Air-Pressure Switch (for units larger than 15 tons (50 kW)): Indicates dirty filters.

M. Controls
1. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.
2. Time-Delay Relay: Five-minute delay to prevent compressor cycling.
3. Adjustable Thermostat: Unit mounted **OR** Remote, **as directed**, to control the following:
   a. Supply fan.
   b. Compressor.
   c. Condenser.
   d. Hot-water coil valve.
   e. Steam coil valve.
   f. Electric heater.
4. System Selector Switch: Heat-off-cool **OR** Off-heat-auto-cool, **as directed**.
5. Fan Control Switch: Auto-on.
6. Time Clock, **as directed**: Cycle unit on and off.
7. Microprocessor Control Panel (for units larger than 15 tons (50 kW)): Controls unit functions, including refrigeration and safety controls, and the following:
   a. Supply fan.
   b. Supply-fan motor speed.
   c. Compressors.
   d. Air-cooled condenser.
   e. Cooling tower pump.
   f. Modulating, hot-water coil valve.
   g. Modulating, steam coil valve.
   h. Multistep, electric heater.
   i. Time-of-day control to cycle unit on and off.
   j. Night-heat, morning warm-up cycle.
   OR
   Microprocessor Control Panel (for units larger than 15 tons (50 kW)): Controls unit functions, including refrigeration and safety controls, and the following:
   k. Supply fan.
   l. Supply-fan motor speed.
   m. Economizer control.
   n. Compressors.
   o. Air-cooled condenser.

p. Cooling tower pump.
q. Modulating, hot-water coil valve.
r. Modulating, steam coil valve.
s. Multistep, electric heater.
t. Panel-mounted control switch to operate unit in remote or local control mode, or to stop or reset.
u. Panel-mounted indication of the following:
   1) Operating status.
   2) System diagnostics and safety alarms.
   3) Supply-air temperature set point.
   4) Zone heating-temperature set point.
   5) Supply-air pressure set point.
   6) Economizer minimum position set point.
   7) Supply-air-pressure, high-limit set point.
v. Time-of-day control to cycle unit on and off.
w. Night-heat, morning warm-up cycle.

N. Ventilation Options For Units 15 Tons (50 kW) And Smaller
1. Barometric Outside-Air Damper: Adjustable-blade damper allowing induction of up to 25 percent outside air when evaporator fan is running.
2. Motorized Outside-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outside air; with spring-return, low-voltage damper motor.
3. Economizer: Damper assembly allowing induction of up to 100 percent outside air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.
4. Energy-Recovery Ventilator: Assembly of desiccant-coated, heat-recovery wheels and centrifugal exhaust fans to transfer approximately 67 percent of the difference between the sensible and latent heat of outside and exhaust air.

O. Economizer Options For Units Larger Than 15 Tons (50 kW)
1. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outside air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.
2. Water-Side Economizer: Mechanically cleanable, aluminum-fin, copper-tube coil assembly, two **OR** four, **as directed**, rows deep, allowing precooling of inlet air using condenser water; with piping and bypass control valves.

1.3 EXECUTION

A. Installation
1. Install units level and plumb.
2. Anchor units to structure.
3. Install seismic restraints.
4. Install static-pressure probe (for units larger than 15 tons (50 kW) equipped with inlet vanes).
5. Install water-cooled units with thermometer and pressure gage at the water supply and return connection.
6. Install vibration spring isolators under base of unit, with minimum static deflection of 1 inch (25 mm). Refer to Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
   a. Water Coil Connections: Comply with requirements in Division 15 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on

the supply connection and with throttling-duty valve and union or flange on the return connection.

b. Remote Water-Cooled Condenser Connections: Comply with requirements in Division 15 Section "Hydronic Piping". Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.

c. Steam Coil Connections: Comply with requirements in Division 15 Section "Steam And Condensate Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.

2. Refrigerant Piping: Comply with applicable requirements in Division 15 Section "Refrigerant Piping". Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.
3. Install piping adjacent to unit to allow service and maintenance.
4. Duct Connections: Duct installation requirements are specified in Division 15 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to self-contained air-conditioners with flexible duct connectors. Flexible duct connectors are specified in Division 15 Section "Duct Accessories".
5. Ground equipment according to Division 16 Section "Grounding And Bonding".
6. Electrical Connections: Comply with requirements in Division 15 for power wiring, switches, and motor controls.

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:

a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

2. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.

a. Complete installation and startup checks according to manufacturer's written instructions.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 15770c

SECTION 15770d - UNIT VENTILATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for unit ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes unit ventilators and accessories with the following heating and cooling features:
   a. Hydronic, Steam, and Electric heating coil.
   b. Hydronic, Steam,and Electric reheat coil.
   c. Hydronic and Direct-expansion refrigerant cooling coil.

C. Definitions
1. BAS: Building automation system.
2. HGBP: Hot-gas bypass.

D. Submittals
1. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   a. Plans, elevations, sections, and details.
   b. Details of anchorages and attachments to structure and to supported equipment.
   c. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that unit ventilators, accessories, and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.
3. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Compressor failure.
      2) Condenser coil leak.
   b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Substantial Completion.
   c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Substantial Completion.
   d. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Units
1. Description: Factory-packaged and -tested units rated according to ARI 840, ASHRAE 33, and UL 1995, including finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in blow-through **OR** draw-through, **as directed**, configuration, and hydronic cooling coil.

B. Cabinets
1. Insulation: Minimum 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
   a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
   b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Drain Pans: Plastic **OR** Insulated galvanized steel with plastic liner, **as directed**, formed as required by ASHRAE 62.1-2004. Drain pan shall be removable, **as directed**.
3. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors, **as directed**.
   a. Steel components exposed to moisture shall be hot-dip galvanized after fabrication.
4. Cabinet Finish: Baked-on primer ready for field painting.
5. Cabinet Finish: Baked enamel, in manufacturer's standard **OR** custom, **as directed**, paint color as selected by the Owner.
6. Indoor-Supply-Air Grille: Steel **OR** Aluminum, **as directed**, double deflection, adjustable **OR** adjustable linear bar, **as directed**.
7. Return-Air Inlet: Front toe space **OR** Back inlet with top inlet grille, **as directed**.
8. End Panels: Matching material and finish of unit ventilator.
9. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
   a. Louver Configuration: Horizontal **OR** Vertical, **as directed**, rain-resistant louver.
   b. Louver Material: Aluminum **OR** Steel, **as directed**.
   c. Bird Screen: 1/2-inch (13-mm) mesh screen on interior side of louver.
   d. Decorative Grille: On outside of intake.
   e. Finish: Anodized aluminum **OR** Baked enamel, **as directed**, color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.

C. Coils
1. Test and rate unit ventilator coils according to ASHRAE 33.
2. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

3. Steam Coils: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).
4. Electric-Resistance Heating Coils: Nickel-chromium heating wire or tubular elements in coil fins, free of expansion noise and hum, with fuses in terminal box for overcurrent protection, and continuous limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
5. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.

D. Indoor Fan
1. Fan and Motor Board: Removable.
   a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels; and aluminum, painted-steel, or galvanized-steel fan scrolls.
   b. Fan Shaft and Bearings: Hollow steel shaft with permanently lubricated, resiliently mounted bearings.
   c. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   d. Wiring Termination: Connect motor to chassis wiring with plug connection.

E. Dampers
1. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric **OR** pneumatic, **as directed**, actuator.
2. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric **OR** pneumatic, **as directed**, actuator.
3. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon bearings; with factory-mounted electric **OR** pneumatic, **as directed**, actuator.
4. Comply with ASHRAE/IESNA 90.1-2004.

F. Accessories
1. Exhaust Shutter: Barometric **OR** Motorized, modulating, **as directed**, type designed to limit room pressure to maximum 0.10-inch wg (25 kPa) with steel **OR** aluminum **OR** fabric, **as directed**, damper blades including edge and end seals, in galvanized-steel frame with outdoor **OR** indoor **OR** outdoor and interior, **as diredcted**, wall grille.
2. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
3. Insulated false back with gasket seals on wall and outdoor-air plenum.
   a. Insulation: Minimum 1/2-inch (13-mm) **OR** 1-inch (25-mm), **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
      1) Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
      2) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
4. Return-air plenum, 6 inches (150 mm) thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
5. Duct flanges for supply-, return-, and outdoor-air connections.
6. Radiation Grille: Steel **OR** Aluminum, **as directed**, linear-bar **OR** stamped, **as directed**, grille with finish to match discharge-air grille.

7. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   a. Washable Foam: 70 percent arrestance and 3 MERV.
      OR
      Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
      OR
      Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
8. Energy Recovery Wheel:
   a. Casing: Steel with manufacturer's standard paint coating and with the following:
      1) Integral purge section.
      2) Casing seals on periphery of rotor, on duct divider, and on purge section.
      3) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
   b. Rotor: Corrugated-aluminum, segmented wheel strengthened with radial spokes, and having nontoxic, noncorrosive silica-gel desiccant coating. Construct media for passing maximum 800-micrometer solids and maximum 0.04 percent cross contamination by volume of exhaust air. Drive rotor with belt around outside of rotor.
   c. Defrost Coils: Electric defrost coil in the exhaust airstream.
   d. Drive: Fractional horsepower motor and gear reducer, with speed changed by adjustable variable frequency controller.
   e. Inlet and Discharge Fans: Forward curved, centrifugal; resiliently mounted with flexible duct connections.
      1) Motor and Drive: Permanently lubricated, direct driven. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   f. Filters: 1-inch- (25-mm-) thick, disposable type, mounted in galvanized-steel frame upstream of energy recovery wheel in both supply and exhaust airstreams.
   g. Electrical: Single electrical connection from attached unit ventilator.

G. Factory Hydronic Piping Package
1. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M Type C), **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Crossover piping, NPS 1-1/2 (DN 40) **OR** NPS 2 (DN 50), **as directed**, with shutoff valves.
2. Control Valves: Electric **OR** Pneumatic, **as directed**, actuators compatible with terminal controller and building controls.
   a. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for dual-temperature-water coil.
   b. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
   c. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for hot-water heating coil.
   d. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve for hot-water reheat coil.
3. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
   a. Length: 24 inches (600 mm) **OR** 36 inches (900 mm), **as directed**.
   b. Minimum Diameter: Equal to unit ventilator connection size.
4. Isolation Valves, Strainers, Unions, and Balance Valves:
   a. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and galvanized-steel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.
   b. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

c. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
d. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
e. Wrought-Copper Unions: ASME B16.22.

H. Remote Condensing Units
1. Description: Factory assembled and tested; consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
2. Casing: Steel with baked-enamel finish; removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
   a. Casing Finish: Baked enamel, in manufacturer's standard **OR** custom, **as directed**, paint color as selected by the Owner.
3. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
   a. Antirecycle timer.
   b. High-pressure cutout.
   c. Low-pressure cutout or loss-of-charge switch.
   d. Internal thermal-overload protection.
   e. Current and voltage sensitive safety devices.
4. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."
6. Refrigerant Piping Materials:
   a. Drawn-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).
   b. Annealed-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type K (ASTM B 88M, Type A), **as directed**.
   c. Wrought-Copper Fittings: ASME B16.22.
7. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
8. Low ambient controls to permit operation down to 45 deg F (7 deg C).
9. Crankcase heater.
10. Charging and service fittings on exterior of casing.
11. Filter dryer.
12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
15. Condenser Fan: Direct-drive, aluminum propeller fan; motor with thermal-overload protection.
   a. Motor: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
16. Accessories: Polyethylene mounting base to provide a permanent foundation.

I. Integral Cooling Chassis
1. Description: Assembly mounted within unit ventilator, factory assembled and tested; consisting of compressors, condenser coils, fans, motors, and refrigerant receivers; removable for maintenance, with plug and receptacle connections for control and power wiring. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
2. Casing: Galvanized steel with removable panels for access to controls and refrigerant piping.
3. Exterior Louver: Extruded aluminum.

4. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
   a. Antirecycle timer.
   b. High-pressure cutout.
   c. Low-pressure cutout or loss-of-charge switch.
   d. Internal thermal-overload protection.
   e. Current- and voltage-sensitive safety devices.
5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."
6. Refrigerant Piping Materials:
   a. Drawn-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).
   b. Annealed-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type K (ASTM B 88M, Type A), **as directed**.
   c. Wrought-Copper Fittings: ASME B16.22.
7. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
8. Low ambient controls to permit operation down to 45 deg F (7 deg C).
9. Crankcase heater.
10. Charging and service fittings.
11. Filter dryer.
12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
15. Direct-Driven Condenser Fan: Forward curved, double width, centrifugal; thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
    a. Motor: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

J. Basic Unit Controls
1. Control devices and operational sequences are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
   OR
   Basic Unit Controls:
   a. Control voltage transformer.
   b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
      1) Heat-cool-off switch.
      2) Fan on-auto switch.
      3) Fan-speed switch.
      4) Manual **OR** Automatic, **as directed**, changeover.
      5) Adjustable deadband.
      6) Concealed **OR** Exposed, **as directed**, set point.
      7) Concealed **OR** Exposed, **as directed**, indication.
      8) Degree F **OR** Degree C, **as directed**, indication.
   c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
      1) Concealed **OR** Exposed, **as directed**, set point.
      2) Concealed **OR** Exposed, **as directed**, indication.
   d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
   e. Unoccupied-period-override push button.
   f. Data entry and access port.
      1) Input data includes room temperature and humidity set points, and occupied and unoccupied periods.
      2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
2. DDC, **as directed**, Terminal Controller:

a. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than 38 deg F (3 deg C) enters coils.
b. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
c. Unoccupied Period Override Operation: Two, **as directed**, hours.
d. Dual-Temperature Coil Operation:
   1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat set point.
   2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
e. Hydronic Cooling-Coil Operation:
   1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to provide cooling if room temperature exceeds thermostat set point.
   2) Unoccupied Periods: Close control valve.
f. Refrigerant-Coil Operation:
   1) Occupied Periods: Start compressor to maintain room temperature.
   2) Unoccupied Periods: Stop compressor cooling **OR** Cycle compressor for heating to maintain setback temperature, **as directed**.
g. Supplemental, **as directed**, Heating-Coil Operation:
   1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
   2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
   3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below 25 deg F (4 deg C).
h. Reheat-Coil Operation:
   1) Humidity Control for Occupied Periods: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
   2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
i. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake during occupied periods, and close during unoccupied periods.
j. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than 60 deg F (15 deg C).
k. Carbon Dioxide Sensor Operation: During occupied periods, reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 800-ppm concentration.
l. Face-and-Bypass Damper Operation: Position damper to face of coils until room temperature equals thermostat set point; bypass after room-temperature set point is achieved.
m. Cooling Lockout: During economizer cycle operation, block out cooling.
n. HGBP: Open HGBP solenoid valve to maintain minimum suction pressure at compressor.
o. Energy Recovery Wheel Operation:
   1) Factory-mounted and -wired, starting relay and manual motor starter for field wiring.
   2) Occupied period is established by remote signal **OR** room occupancy sensor, **as directed**.
   3) Energy recovery wheel and inlet and discharge fans operate during occupied periods after room temperature set point has been achieved.

4) Energy recovery wheel operates during occupied periods, but stops when unit ventilator controls call for cooling, and outdoor-air temperatures permit free air cooling.
5) Energy recovery wheel and fans stop during unoccupied periods.

p. Controller shall have volatile-memory backup.

3. BAS Interface Requirements:
   a. Interface relay for scheduled operation.
   b. Interface relay to provide indication of fault at the central workstation.
   c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
      1) Adjust set points.
      2) Unit ventilator start, stop, and operating status.
      3) Data inquiry to include outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
      4) Occupied and unoccupied schedules.
4. Electrical Connection: Factory wire motors and controls for a single electrical connection.

K. Metal Shelves And Cabinets
1. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:
   a. Open Shelving with Reinforced Shelves:
      1) Return-air plenum **OR** Radiation enclosure, **as directed**, and aluminum bar grille with finish to match unit ventilator grille.
      2) Through-piping enclosure with solid top.
   b. Closed Shelving with Reinforced Shelves:
      1) Return-air plenum **OR** Radiation enclosure, **as directed**, and aluminum bar grille with finish to match unit ventilator grille.
      2) Through-piping enclosure with solid top.
      3) Two sliding doors with key-operated locks.
   c. Utility compartment with access panel with key-operated lock.
   d. Wall and corner filler sections, and end panels finished to match shelving.
2. Painted Finish: Manufacturer's standard **OR** custom, **as directed**, baked enamel, in color selected by the Owner, applied to shelving before shipping.
3. Cabinet Top: Plastic-laminate top in color and pattern selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.

1.3 EXECUTION

A. Installation
1. Install unit ventilators to comply with NFPA 90A.
2. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum 0.25-inch (6.35-mm) static-deflection, elastomeric vibration isolation hanger **OR** 1.0-inch (25-mm) static-deflection spring hangers, **as directed**. Vibration isolators are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1525 mm), **as directed**, above finished floor.
4. Refer to Division 15 Section "Condensing Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
   a. Install piping adjacent to machine to allow service and maintenance.

b. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
c. Connect condensate drain to indirect waste.

2. Install refrigerant piping as required by Division 15 Section "Refrigerant Piping", and add refrigerant as required to compensate for length of piping.
3. Connect supply and return ducts to unit ventilators with flexible duct connectors specified in Division 15 Section "Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.
4. Ground equipment according to Division 16 Section "Grounding And Bonding".
5. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
   c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
   d. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F (8.3 deg C) higher, or 20 deg F (11 deg C) lower, than room temperature.
2. Remove and replace malfunctioning units and retest as specified above.

D. Adjusting

1. Adjust initial temperature and humidity set points.
2. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

END OF SECTION 15770d

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Task	Specification	Specification Description
15771	15770a	Packaged, Outdoor, Central-Station Air-Handling Units
15772	15770	Packaged Terminal Air Conditioners
15772	15770a	Packaged, Outdoor, Central-Station Air-Handling Units
15772	15661b	Split-System Air-Conditioning Units

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SECTION 15773 - COMPUTER-ROOM AIR-CONDITIONERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for computer-room air-conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Floor-mounted computer-room air conditioners, 6 tons (21 kW) and larger.
b. Floor-mounted computer-room air conditioners, 5 tons (18 kW) and smaller.
c. Ceiling-mounted computer-room air conditioners.
d. Console computer-room air conditioners.

C. Definition
1. BAS: Building automation system.

D. Performance Requirements
1. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
4. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.
5. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.
6. Field quality-control reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
a. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

b. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
4. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Compressors: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Substantial Completion.
   b. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
   c. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.2 PRODUCTS

A. Floor-Mounted Units 6 Tons (21 kW) And Larger
1. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls.
2. Cabinet and Frame: Welded steel, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.
   a. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
   b. Insulation: Thermally and acoustically insulate cabinet interior with 1-inch- (25-mm-) thick duct liner.
   c. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
   d. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as selected from manufacturer's standard colors **OR** to match computer equipment, **as directed**.
   e. Floor Stand: Welded tubular steel with adjustable legs and vibration isolation pads.
3. Supply-Air Fan(s):
   a. Double-inlet, forward-curved centrifugal fan(s); statically and dynamically balanced.
   b. Drive: V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable- and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.
4. Refrigeration System:
   a. Compressors: Semihermetic reciprocating; with suction-gas-cooled, 1750-rpm motors; thermal overloads; oil sight glass; suction-line strainer; and reversible oil pumps; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.

      OR

      Compressors: Hermetic reciprocating; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.

      Compressors: Hermetic scroll; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.

b. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.

c. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.

d. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.

1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

e. Integral, Water-Cooled Refrigerant Condenser: Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII **OR** Coaxial tube-in-tube type, **as directed**, with liquid-line stop valve and head-pressure-actuated, two-way **OR** three-way, **as directed**, regulating valve. Terminate fluid connections outside cabinet.

1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

OR

Remote Air-Cooled Refrigerant Condenser: Corrosion-resistant cabinet, copper-tube aluminum-fin coils arranged for two circuits, multiple direct-drive propeller fans with permanently lubricated ball bearings, and single-phase motors with internal overload protection and integral electric control panel and disconnect switch, **as directed**. Control capacity by cycling fans **OR** modulating fan speeds **OR** three-way refrigerant bypass with receiver and isolation valve, **as directed**.

5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating two-way **OR** three-way, **as directed**, control valve.

a. Cooling Medium: Water **OR** Glycol solution, **as directed**.

b. Control Valve: Class 125 body.

1) Maximum Pressure Drop: 3 psig (21 kPa) **OR** 5 psig (35 kPa), **as directed**, at design flow rate.

2) Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

c. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

OR

Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, multiple direct-drive propeller fans with fan guards, and single-phase motors with internal overload protection and integral electric control panel. Control capacity by cycling fans.

d. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing one **OR** two, **as directed**, centrifugal pump(s) with mechanical seals; electrical-control cabinet with starters, lead-lag switch, automatic switchover, and alarm light.

a. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, check valves in pump discharge, unions, and pressurized expansion tank with air purge vent and system-charging connection.

b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).

c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

7. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.

OR

Refrigerant Heating Coil: Hot-gas coil of seamless copper tubes expanded into aluminum fins with three-way solenoid valve on first-stage refrigerant circuit.

OR

Hot-Water Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve and strainer.

a. Control Valve: Class 125 body.
   1) Maximum Pressure Drop: 3 psig (21 kPa) **OR** 5 psig (35 kPa), **as directed**, at design flow rate.
   2) Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

OR

Steam Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve, strainer, and float-and-thermostatic trap.

b. Control Valve: Class 125 body.
   1) Maximum Pressure Drop (15-psig (103-kPa) Steam): 80 percent of inlet steam pressure.
   2) Close-Off (Differential) Pressure Rating: 150 percent of operating (inlet) pressure.

8. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame with 2-inch- (50-mm-) thick, disposable, glass-fiber prefilter, **as directed**.
   a. Thickness: 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
   b. Initial Resistance: as directed by the Owner.
   c. Recommended Final Resistance: as directed by the Owner.
   d. Arrestance (ASHRAE 52.1): 90 percent.
   e. Merv (ASHRAE 52.2): 7.
9. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and using condensate water from cooling coils with stainless-steel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.
10. Evaporative Pan Humidifier: Stainless-steel pan and cover, serviceable without disconnecting water, drain, or electrical connections; prepiped with stainless-steel or brass float-valve mechanism; electric-resistance heating coil; low-water-cutoff switch; flush-cycle timer; and solenoid drain valve.
11. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
    a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
    b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
    c. Drain Cycle: Field-adjustable drain duration and drain interval.
12. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.
13. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
14. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.
    a. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
    b. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
    c. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.

15. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.
    a. Malfunctions:
        1) Power loss.
        2) Loss of airflow.
        3) Clogged air filter.
        4) High room temperature.
        5) Low room temperature.
        6) High humidity.
        7) Low humidity.
        8) Smoke/fire.
        9) Water under floor.
        10) Supply fan overload.
        11) Compressor No. 1 - Overload.
        12) Compressor No. 1 - Low Pressure.
        13) Compressor No. 1 - High Pressure.
        14) Compressor No. 2 - Overload.
        15) Compressor No. 2 - Low Pressure.
        16) Compressor No. 2 - High Pressure.
    b. Digital Display:
        1) Control power on.
        2) Humidifying.
        3) Dehumidifying.
        4) Compressor No. 1 - Operating.
        5) Compressor No. 2 - Operating.
        6) Heat operating.
        7) Economy cooling.
    c. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.
    d. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.
        1) Hardwired Points:
            a) Monitoring: On-off status, common trouble alarm **OR** space temperature **OR** space relative humidity, **as directed**.
            b) Control: On-off operation, space temperature set-point adjustment **OR** space relative humidity set-point adjustment, **as directed**.
        2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

B. Floor-Mounted Units 5 Tons (18 kW) And Smaller
1. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.
2. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch- (25-mm-) thick duct liner.
    a. Floor Stand: Welded tubular steel with adjustable legs and vibration isolation pads.
    b. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.
4. Refrigeration System:

a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
b. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
c. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
   1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
e. Integral, Water-Cooled Refrigerant Condenser: Brazed-plate type with liquid-line stop valve and head-pressure-actuated, two-way regulating valve.
   1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

   OR

   Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct **OR** belt, **as directed**, driven.
   2) Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating three-way control valve.
   a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
   b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

   OR

   Remote Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.
   c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
   a. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
   b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
   c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
8. Filter: 2-inch- (50-mm-) thick, disposable, glass-fiber media.
   a. Initial Resistance: as directed by the Owner.
   b. Recommended Final Resistance: as directed by the Owner.
   c. Arrestance (ASHRAE 52.1): 90 percent.
   d. Merv (ASHRAE 52.2): 7.
9. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.
10. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
c. Drain Cycle: Field-adjustable drain duration and drain interval.

11. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
12. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-, **as directed**, control modules, humidity contactor, **as directed**, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.

C. Ceiling-Mounted Units

1. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of 24 by 48 inches (610 by 1220 mm).
2. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch- (13-mm-) thick duct liner.
   a. Integral factory-supplied supply and return grille to fit ceiling grid kit of 24 by 48 inches (610 by 1220 mm), with filter.
   b. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
4. Refrigeration System:
   a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   b. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   c. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
   d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
      1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
   e. Integral, Water-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube **OR** Brazed-plate, **as directed**, type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
      1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

      OR

      Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct driven.
   f. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.
   a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
   b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

   OR

   Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
   a. Piping: Interconnecting piping, to and from remote, air-cooled glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
   b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.
8. Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.
   a. Initial Resistance: as directed by the Owner.
   b. Recommended Final Resistance: as directed by the Owner.
   c. Arrestance (ASHRAE 52.1): 90 percent.
   d. Merv (ASHRAE 52.2): 7.
9. Atomizing Humidifier: Centrifugal atomizer with stainless-steel pan, demister pad, and solenoid valve.
10. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
    a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
    b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
    c. Drain Cycle: Field-adjustable drain duration and drain interval.
11. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
12. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-, **as directed**,control modules, humidity contactor, **as directed**, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.

D. Console Units
1. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.
2. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.
   a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.
4. Refrigeration System:
   a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
   b. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
   c. Refrigerant: R-22 **OR** R-407C **OR** R-410A, **as directed**.
   d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
      1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

e. Integral, Water-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube **OR** Brazed-plate, **as directed**, type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
OR
Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct driven.

f. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.
   a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
   b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

   OR
   Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motor with internal overload protection.
6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
   a. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
   b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
8. Filter: Cleanable.
   OR
   Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.
   a. Initial Resistance: as directed by the Owner.
   b. Recommended Final Resistance: as directed by the Owner.
   c. Arrestance (ASHRAE 52.1): 90 percent.
   d. Merv (ASHRAE 52.2): 7.
9. Electrode Steam Humidifier: Self-contained and microprocessor controlled; with replaceable cylinder.
10. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
11. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature- and humidity-, **as directed**,control modules. Provide solid-state, unit-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.

E. Fan Motors
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.

1.3 EXECUTION

A. Installation

1. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B, **as directed**.
2. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
3. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support weight of computer-room air conditioner.
   a. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required.
   b. Comply with requirements for hangers and supports specified in Division 15 Section "Hangers And Supports For Hvac Piping And Equipment".
4. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
5. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
6. Glycol-Solution Pump Package Mounting: Install using elastomeric pads **OR** elastomeric mounts, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Water and Drainage Connections: Comply with applicable requirements in Division 15 Section "Domestic Water Piping". Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
4. Hot-Water Heating Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping". Provide shutoff valves in inlet and outlet piping to heating coils.
5. Steam and Condensate Piping: Comply with applicable requirements in Division 15 Section "Steam And Condensate Piping". Provide shutoff valves in steam inlet and steam trap in condensate outlet piping to heating coils.
6. Condenser-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping". Provide shutoff valves in water inlet and outlet piping on water-cooled units.
7. Refrigerant Piping: Comply with applicable requirements in Division 15 Section "Refrigerant Piping". Provide shutoff valves and piping.

C. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   b. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.
5. After startup service and performance test, change filters and flush humidifier.

D. Adjusting

1. Adjust initial temperature and humidity, **as directed**, set points.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
3. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

E. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 15773

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SECTION 15781 - HUMIDIFIERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for humidifiers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following humidifiers:
a. Atomizing.
b. Steam injection.
c. Self-contained.
d. Heated pan.
e. Heat exchanger.

C. Definition
1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

D. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.2 Products

A. Water-Pressure Atomizing Humidifiers
1. Nozzles: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel.
2. Manifold: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel piping.
3. Droplet Filter: Biocide-treated polyethylene with maximum 0.30-inch wg (75-Pa) resistance.
4. Piping and Fittings: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel pipe and fittings.
OR
Piping and Fittings: ASTM B 88 (ASTM B 88M), Type L copper pipe and wrought-copper fittings with brazed joints.
5. Water Pump: Enclosed belt-drive ceramic plunger pump with stainless-steel **OR** bronze, **as directed**, heads, and single **OR** variable, **as directed**,-speed, totally enclosed, fan-cooled motor.
6. Final Water-Filter Efficiency: Minimum 98 percent retention of suspended particles 10 **OR** 20, **as directed**, microns and larger from makeup water.

7. Final Water-Filter Pressure Drop: Maximum 2 psig (14 kPa) at design flow when clean, and <**Insert value**> when dirty, **as directed**.
8. Pump Controls:
   a. Cycle **OR** Vary speed of, **as directed**, motor to satisfy humidistat.
   b. High-pressure solenoid valve for each control zone shown on Drawings.
   c. Building automation system interface for each control zone for start/stop and status indication and control at central workstation.
9. Dispersion Fan:
   a. Aluminum blade propeller fan with finger guard and single-speed motor interlocked to operate with humidifier.
   b. Fan Mounting: Above and behind manifold on bracket integral to wall-mounting manifold.
10. Accessories:
   a. Humidistat: Wall **OR** Return-duct, **as directed**,-mounting, solid-state, electronic-sensor controller capable of full-modulation or cycling control.
   b. Duct-mounting, high-limit humidistat.
   c. Airflow switch for preventing humidifier operation without airflow.

B. Compressed-Air Atomizing Humidifiers
1. Nozzles: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel.
2. Manifold: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel piping.
3. Droplet Filter: Biocide-treated polyethylene with maximum 0.30-inch wg (75-Pa) resistance.
4. Piping and Fittings: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel pipe and fittings.
5. Compressed-Air and Water, **as directed**, Piping and Fittings: ASTM B 88 (ASTM B 88M), Type L copper pipe and wrought-copper fittings with soldered joints.
6. Final Water-Filter Efficiency: Minimum 98 percent retention of suspended particles 10 **OR** 20, **as directed**, microns and larger from makeup water.
7. Final Water-Filter Pressure Drop: Maximum 2 psig (14 kPa) at design flow when clean, and <**Insert value**> when dirty, **as directed**.
8. Air and Water Solenoid Controls:
   a. Cycle valves to satisfy humidistat.
   b. Solenoid valves for each control zone shown on Drawings.
   c. Building automation system interface for each control zone for start/stop and status indication and control at central workstation.
9. Dispersion Fan:
   a. Aluminum blade propeller fan with finger guard and single-speed motor interlocked to operate with humidifier.
   b. Fan Mounting: Above and behind manifold on bracket integral to wall-mounting manifold.
10. Accessories:
   a. Humidistat: Wall **OR** Return-duct, **as directed**,-mounting, solid-state, electronic-sensor controller capable of full-modulation or cycling control.
   b. Duct-mounting, high-limit humidistat.
   c. Airflow switch for preventing humidifier operation without airflow.

C. Steam-Injection Humidifiers
1. Manifold: ASTM A 666, Type 304 stainless steel, steam jacketed, **as directed**; insulated with 1/2-inch (13-mm) fiberglass and stainless-steel jacket; and , **as directed**,extending the full width of duct or plenum with mounting brackets at ends.
2. Discharge Nozzle and Dispersion Fan:
   a. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and single-speed motor interlocked to operate with humidifier.
   b. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.
3. Steam Separator: Cast iron **OR** ASTM A 666, Type 304 stainless steel, **as directed**, with separate, **as directed**, humidifier control valve.
4. Humidifier Control Valve:

a. Actuator: Pneumatic **OR** Electric, **as directed**, modulating with spring return.
OR
Actuator: As specified in Division 15 Section "Hvac Instrumentation And Controls".

5. Steam Trap: Inverted-bucket type, sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) inlet pressure.
6. Accessories:
   a. Wall **OR** Return-duct, **as directed**,-mounting humidistat.
   b. Duct-mounting, high-limit humidistat.
   c. Aquastat mounted on steam condensate return piping to prevent cold operation of humidifier.
   d. In-line strainer.
   e. Airflow switch for preventing humidifier operation without airflow.

D. Self-Contained Humidifiers
1. Electric-Resistance Heater Container: Cleanable, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel. Comply with UL 499.
2. Electrode Cylinder: Replaceable plastic assembly with disposable ionic bed inserts, **as directed**. Comply with UL 499.
3. Gas-Fired Steam Generator: Factory assembled and tested.
   a. Standard: Fabricate and label steam generator to comply with CSA.
   b. Maximum Steam Pressure: 10 inches wg (2488 Pa).
   c. Burner Type: Natural-gas **OR** Propane, **as directed**, fired with modulating, low NOx infrared burner, minimum 82 percent efficient.
   d. Gas Train: Safety shutoff valves, gas cock, strainer, pressure-regulating valve.
   e. Ignition: Hot-surface ignition with flame safety system.
   f. Combustion Chamber: Sealed with outdoor-air and flue-vent connections.
   g. Heat-Exchanger Tank: Cleanable, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating and disposable ionic bed inserts, **as directed**.
4. Manifold: Stainless-steel tube with integral fan to discharge vapor directly into occupied space.
OR
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube extending across entire width of duct or plenum and equipped with mounting brackets on ends.
5. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping.
6. Control Panel:
   a. Factory-wired disconnect switch.
   b. Liquid-crystal display.
   c. Programmable keyboard.
   d. Set-point adjustment.
   e. Warning signal indicating end of replaceable cylinder or ionic bed insert, **as directed**, life.
   f. Low-voltage, control circuit.
   g. Diagnostic, maintenance, alarm, and status features.
   h. High-water sensor **OR** float, **as directed**, to prevent overfilling.
7. Controls:
   a. Microprocessor-based control system for modulating or cycling control, and start/stop and status monitoring for interface to central HVAC instrumentation and controls.
   b. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
   c. Field-adjustable timer to control drain cycle for flush duration and interval.
   d. Controls shall drain tanks if no demand for humidification for more than 72 hours.
   e. Conductivity **OR** Float, **as directed**,-type level controls.
8. Accessories:
   a. Humidistat: Wall **OR** Return-duct, **as directed**,-mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
   b. Duct-mounting, high-limit humidistat.
   c. Airflow switch for preventing humidifier operation without airflow.

E. Heated-Pan Humidifiers
1. Heat Source: Hot water **OR** Steam **OR** Electric resistance, **as directed**.
2. Comply with UL 499.
3. Pan and Heat-Exchange Piping: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating, overflow, and drain fittings. Include disposable ionic bed inserts, **as directed**.
4. Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel, duct-mounting, single- or manifold-grid connected to heated-pan housing with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets at both ends.
   OR
   Manifold: Inverted, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel U-tube with humidifier mounted directly under the duct.
   OR
   Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube with flexible hose to connect to humidifier, integral fan to discharge vapor directly into occupied space, and wall- or ceiling-mounting brackets.
5. Controls:
   a. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
   b. Field-adjustable timer to control drain cycle for flush duration and interval.
   c. Conductivity **OR** Float, **as directed**,-type level controls.
6. Piping Specialties: Inlet strainer, control valve, and steam trap.
7. Piping Specialties: Inlet strainer and control valve.
8. Accessories:
   a. Humidistat: Wall **OR** Return-duct, **as directed**,-mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
   b. Duct-mounting, high-limit humidistat.
   c. Airflow switch for preventing humidifier operation without airflow.

F. Heat-Exchanger Humidifiers
1. Fabricate and label steam generator to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Heat Exchanger: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating, overflow, and drain fittings. Include disposable ionic bed inserts, **as directed**.
3. Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel, steam-jacketed, **as directed**, duct-mounting, single- or manifold-grid connected to steam generator with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets for both ends. Insulate with 1/2-inch (13-mm) fiberglass and stainless-steel jacket extending full width of duct or plenum with mounting brackets at ends, **as directed**.
   OR
   Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube with flexible hose to connect to humidifier and integral fan to discharge vapor directly into occupied space. Manifold shall have wall- or ceiling-mounting brackets.
4. Controls:
   a. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
   b. Field-adjustable timer to control drain cycle for flush duration and interval.
   c. Conductivity **OR** Float, **as directed**,-type level controls.
5. Accessories:
   a. Humidistat: Wall **OR** Return-duct, **as directed**,-mounting, solid-state, electronic-sensor controller capable of full modulation.
   b. Duct-mounting, high-limit humidistat.
   c. Airflow switch for preventing humidifier operation without airflow.

1.3 EXECUTION

A. Installation
1. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1-2004, **as directed**.
2. Seal humidifier manifold duct or plenum penetrations with flange.
3. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
4. Install galvanized **OR** stainless, **as directed**,-steel drain pan under each manifold mounted in duct.
   a. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1-2004, **as directed**.
   b. Connect to condensate trap and drainage piping.
   c. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1-2004.
5. Install manifold supply piping pitched to drain condensate back to humidifier.
6. Install drip leg upstream from steam trap a minimum of 12 inches (300 mm) tall for proper operation of trap.
7. Install steam generator level on concrete base. Concrete base is specified in Division 15 Section "Common Work Results For Hvac".
8. Concrete Bases: Anchor steam generator to concrete base.
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
   e. Cast-in-place concrete materials and placement requirements are specified in Division 02.
9. Install seismic restraints on humidifiers. Seismic restraints are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
10. Install gas-fired steam generators according to NFPA 54.

B. Connections
1. Piping installation requirements are specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
   a. Install piping adjacent to humidifiers to allow service and maintenance.
   b. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
2. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.
3. Install piping from safety relief valves to nearest floor drain.
4. Connect gas piping full size to steam-generator, gas-train inlet with union. Gas piping materials and specialties are specified in Division 15 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**.
5. Connect breeching full size to steam-generator outlet. Venting materials are specified in Division 15 Section "Breechings, Chimneys, And Stacks".
6. Connect combustion-air inlet to intake terminal using PVC piping with solvent-cemented joints. Run from boiler connection to outside and terminate adjacent to flue termination.
7. Ground equipment according to Division 16 Section "Grounding And Bonding".
8. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:

a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3. Remove and replace malfunctioning units and retest as specified above.

D. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 15781

SECTION 15785 - DEHUMIDIFICATION UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for mechanical dehumidification units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes packaged, factory-assembled and -tested, refrigerant-type, mechanical dehumidification units designed for outdoor and indoor installation.

C. Performance Requirements
1. Seismic Performance: Dehumidification units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals
1. Product Data: For each dehumidification unit indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. LEED Submittals:
   a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
   b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5, "Systems and Equipment."
3. Shop Drawings: For each dehumidification unit indicated. Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For dehumidification units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
   b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Seismic Qualification Certificates: For <**Insert equipment,**> accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Source quality-control reports.
7. Field quality-control reports.
8. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.

9. Warranty: Sample of special warranty.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
   a. Applicable requirements in ASHRAE 62.1-2004, Section 5, "Systems and Equipment" and Section 7, "Construction and Startup."
   b. Applicable requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

F. Coordination
1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
2. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of dehumidification units that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Compressors: Manufacturer's standard, but not less than two **OR** five, **as directed**, years from date of Substantial Completion.
   b. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Substantial Completion.

1.2 PRODUCTS

A. Casings
1. Casing: Single-wall **OR** Double-wall, **as directed**, construction with corrosion-protective coating and exterior baked-enamel **OR** powder-coated, **as directed**, finish, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.
   a. Access: Removable panels **OR** Hinged access doors, **as directed**, with neoprene gaskets.
   b. Insulation: Minimum 1/2-inch- (13-mm-) thick thermal insulation **OR** 2-inch- (50-mm-) thick, glass-fiber-insulation fill with no metal structure through the insulation, **as directed**.
   c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Drain Pan and Connection: Plastic **OR** Stainless steel, **as directed**; insulated and complying with ASHRAE 62.1-2004, **as directed**.

B. Fans
1. Supply Fans: Forward curved **OR** Backward inclined, **as directed**, centrifugal; galvanized steel with baked-enamel **OR** powder-coated, **as directed**, finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.
2. Exhaust **OR** Return, **as directed**, Fans: Forward curved **OR** Backward inclined, **as directed**, centrifugal; galvanized steel with baked-enamel **OR** powder-coated, **as directed**, finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.
3. Fan Motor: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Enclosure Type: Totally enclosed, fan cooled.

C. Filters

1. Glass Fiber: Minimum 80 percent arrestance according to ASHRAE 52.1, and MERV 5 according to ASHRAE 52.2.
2. Pleated: Minimum 90 percent arrestance according to ASHRAE 52.1, and MERV 7 according to ASHRAE 52.2.

D. Refrigeration System
1. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1.
2. Refrigerant Coils: Copper tubes with mechanically bonded aluminum fins; factory fabricated and tested to comply with ASHRAE 33 and ARI 410; with multiple refrigerant circuits, seamless-copper headers with brazed connections, and galvanized **OR** stainless, **as directed**,-steel frame. Coil and fins shall have a polyester coating. Coils shall have a minimum 300-psig (2070-kPa) working-pressure rating and be factory tested to 450 psig (3105 kPa) and to 300 psig (2070 kPa) while underwater.
3. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
   a. Number of Refrigerant Circuits: Two for compressor capacities more than 7-1/2 tons (26.4 kW).
   b. Refrigerant: R-22 **OR** R-134a **OR** R-407C **OR** R-410A, **as directed**.
      OR
      Refrigerant: R-134a, R-407C, or R-410A.
   c. Capacity Control:
      1) Hot-gas bypass valve and piping on one compressor.
      2) Cycle compressor.
   d. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
   e. High-Pressure Cutout: Manual reset.
   f. Compressor Motor Overload Protection: Manual reset.
   g. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
   h. Defrost Cycle (for ice rinks): Adjustable timer shuts off supply fan. Compressor cycles until suction line temperature confirms thawed evaporator coil. Timer limits defrost time to 10 minutes.
4. Energy Recovery Heat Exchanger (Pool Heater): Cupronickel, coaxial, vented, double-wall construction for potable-water service.

E. Remote-Mounted, Air-Cooled Condenser Unit
1. Casing: Steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Refrigerant Coil: ARI 210/240, copper tube with mechanically bonded aluminum fins; with liquid subcooler.
3. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.
4. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as 0 deg F (minus 18 deg C) by cycling condenser fans and controlling speed of last fan of each circuit.
5. Mounting Base: Polyethylene.

F. Heating Coils
1. Hot-Water Coil: Continuous circuit coil fabricated according to ARI 410.
   a. Tubes: Copper.
   b. Fins: Aluminum **OR** Copper, **as directed**, with fin spacing 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
   c. Fin and Tube Joints: Mechanical bond.
   d. Headers: Cast iron with drain and air vent tappings.
   e. Frames: Galvanized-steel channel, 0.052 inch (1.3 mm).

f. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
   1) Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
g. Source Quality Control: Test to 300 psig (2070 kPa).

2. Steam Coil: Distribution header coil fabricated according to ARI 410, with threaded steam supply and condensate connections.
   a. Tubes: Copper.
   b. Fins: Aluminum **OR** Copper, **as directed**, with fin spacing 0.125 inch (3.18 mm) **OR** 0.091 inch (2.31 mm) **OR** 0.071 inch (1.80 mm) **OR** 0.067 inch (1.70 mm) **OR** 0.056 inch (1.42 mm) **OR** 0.0075 inch (0.19 mm), **as directed**.
   c. Fin and Tube Joints: Mechanical bond.
   d. Headers: Cast iron with drain and air vent tappings.
   e. Frames: Galvanized-steel channel, 0.052 inch (1.3 mm).
   f. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
      1) Working-Pressure Ratings: 100 psig (690 kPa), 400 deg F (205 deg C).
   g. Source Quality Control: Test to 200 psig (1380 kPa).
3. Electric-Resistance Heating Coil: Comply with UL 1995.
   a. Heating Element: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated steel fins continuously brazed to sheath.
      OR
      Heating Element: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
   b. Overtemperature Protection: Disk-type, automatic-reset, thermal-cutout safety device; serviceable through terminal box without removing heater from unit.
   c. Thermal Cutouts: Load carrying, manual reset or replaceable, and factory wired in series with each heater stage.
   d. Control: Disconnecting means, overcurrent protection, and airflow proving switch.

G. Dampers
1. Outdoor-Air Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rod rotating in sintered bronze or nylon bearings. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod. Size for 0 to 25 percent outdoor air, with manual **OR** motorized, **as directed**, operator and filter.
2. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in sintered bronze or nylon bearings with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
3. Outdoor- and Return-Air **OR** Outdoor-, Return-, and Exhaust-Air, **as directed**, Dampers: Parallel-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers mechanically fastened to steel **OR** cadmium-plated steel, **as directed**, operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
4. Outdoor- and Return-Air **OR** Outdoor-, Return-, and Exhaust-Air, **as directed**, Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade **OR** parallel-blade, **as directed**, arrangement with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
5. Damper Operator: 115 **OR** 24, **as directed**,-V ac, close coupled, with gear train sealed in oil and with spring return.

H. Controls
1. Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls" for control equipment and in Division 15 Section "Sequence Of Operation".
2. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
3. Building Automation System Interface: Factory-installed hardware and software to enable the building automation system to monitor, control, and display status and alarms.
4. Operating Control: Space humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.
5. Operating Controls (for indoor pool units with typical manufacturer's control panel): Factory-installed microprocessor controller, capable of being remotely mounted.
   a. Display the following on the face of controller:
      1) System on.
      2) System dehumidifying mode.
      3) System air-conditioning mode.
      4) System outdoor-air (economizer) mode.
      5) System heating pool water.
      6) Auxiliary space heat is operating.
      7) Unit requires service.
      8) Return-air (space) temperature.
      9) Return-air (space) humidity.
      10) Pool-water temperature.
      11) Outdoor-air temperature.
   b. Indicate the following sensor failures on panel:
      1) Airflow: Dirty air filter, blocked airflow, and fan failure.
      2) Refrigerant high and low pressure.
      3) High water temperature.
      4) High and low evaporator temperature.
      5) Low water flow.
      6) Communication fault.
      7) System off.
      8) Antishort cycle delay.
      9) Power failure.
   c. Provide access to the following set points on panel:
      1) Space temperature.
      2) Space relative humidity.
      3) Outdoor ventilation/air-conditioning changeover temperature.
      4) Airflow alarm.
   d. Provide the following displays on panel:
      1) Space temperature.
      2) Space relative humidity.
      3) Outdoor-air temperature.
      4) Supply-air temperature.
      5) Return-air temperature.
      6) Airflow rating.
      7) Air-off evaporator temperature.
      8) Return-air relative humidity.
      9) Service codes.
   e. Provide the following controls on panel:
      1) System on-off, fan continues to run.
      2) Fan on-off.
      3) Service code access.
      4) System dehumidifying mode.
      5) System air-conditioning mode.

6) System outdoor-air (economizer) mode.
7) Auxiliary space heat is operating.
8) Outdoor-air-temperature, conditioned-space-temperature, and control set-point-temperature digital display.
9) Outdoor enthalpy digital display.
10) Filter pressure drop digital display.
11) Status: Airflow, fans, system, unit operation, and operating mode.
12) Alarm digital display.

6. Operating Controls: Factory-installed microprocessor controller.
   a. Factory-installed operator panel with backlit display, capable of being remotely mounted, allows menu-driven display for navigation and control of unit.
   b. Integral clock.
   c. Personal computer interface.
   d. Integral local area network for direct connection to BACnet **OR** LonWorks **OR** MODBUS, **as directed**.
   e. Factory programmed.
   f. Unit-Mounted Sensors:
      1) Airflow switch.
      2) Compressor-discharge temperature.
      3) Evaporator-air temperature.
      4) Pool-water-out temperature.
      5) Pool-water-in temperature.
      6) Relative humidity.
      7) Return-air temperature.
      8) Supply-air temperature.
   g. Integral diagnostics.
   h. Nonvolatile memory.
   i. IP or SI display.
   j. Provide the following status and alarm functions:
      1) System: On-off.
      2) Power failure.
      3) Fan: Off, overload.
      4) Compressor: On, turned off, overload, high pressure, low pressure, overheat, oil failure, and pumpdown.
      5) Evaporator damper closed.
      6) Pool: Low water flow, heating on.
      7) Dehumidification: Call for, on.
      8) Air Conditioning: Call for, on.
      9) System outdoor-air (economizer) mode.
      10) Auxiliary space heat on.
      11) Alarms: Firestat, freezestat, and filters.
   k. Provide the following controls via operator panel:
      1) Compressor auto-off.
      2) Fan auto-off.
      3) Set-Point Adjustments: Relative humidity, temperatures, deadbands, and differentials.
      4) Sensor calibration.
   l. Monitor constant and variable motor loads.
   m. Monitor cooling load.
   n. Monitor economizer cycles.
   o. Monitor ventilation air volumes.

I. Accessories
   1. Water-Cooling Heat Exchanger: Coaxial, vented, double-wall construction; with three-way refrigerant control valve.

2. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.
   a. Operating Voltage: 24-V dc, nominal.
   b. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.
   c. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
   d. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
   e. Sensitivity: Can be tested and adjusted in-place after installation.
   f. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
   g. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
   h. Detector Sensitivity: Between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) of smoke obscuration when tested according to UL 268A.
   i. Integral Thermal Detector: Fixed-temperature type with 135 deg F (57 deg C) setting.
3. Electrical Convenience Outlet: 115-V ac fused, duplex, straight-blade receptacles, separately fused and located inside casing of dehumidification unit or in roof-curb perimeter.

J. Roof Curbs
1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
3. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   a. Materials: ASTM C 1071, Type I or II.
   b. Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm), **as directed**.
   c. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
   d. Liner Adhesive: Comply with ASTM C 916, Type I.
   e. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   f. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.
4. Curb Height: 14 inches (355 mm) **OR** 24 inches (610 mm) **OR** 36 inches (910 mm), **as directed**.
5. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match dehumidification unit; used to anchor unit to the curb and designed for loads at Project site. Comply with requirements in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for wind-load requirements.

K. Source Quality Control
1. Verification of Performance: Factory test and rate dehumidification units according to ARI 910.
2. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to ARI 575.

1.3 EXECUTION

A. Examination
1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Examine roughing-in for hot-water **OR** steam **OR** refrigerant, **as directed**, piping systems to verify actual locations of piping connections before equipment installation.
3. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation

1. Equipment Mounting (for indoor or outdoor equipment supported on slabs-on-grade without vibration isolation devices): Install dehumidification units on concrete base(s). Comply with requirements for concrete base(s) specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Equipment Mounting (for indoor or outdoor equipment supported on concrete equipment base with vibration isolation devices): Install dehumidification units on concrete base(s) using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base(s) specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
   b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
   d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting (for installation of indoor or outdoor equipment on vibration isolation devices without concrete base): Install dehumidification units using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
4. Equipment Mounting (for installation of indoor or outdoor equipment on vibration isolation equipment base): Install dehumidification units on vibration isolation equipment base. Comply with requirements specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. For installation of indoor or outdoor equipment without vibration isolation devices, with seismic restraints, and without concrete base: Install dehumidification units with <**Insert seismic-restraint device**>. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. For indoor units suspended from structure: Install continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support weight of dehumidification unit.
   a. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required.
   b. Comply with requirements for hangers and supports specified in Division 15 Section "Hangers And Supports For Hvac Piping And Equipment".
7. Curb Support (if curbs are furnished with dehumidification units for rooftop installations): Install roof curb on roof structure, level and secure, according to NRCA's "The NRCA Roofing and Waterproofing Manual, Fifth Edition." Install and secure dehumidification units on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
8. Unit Support: Install dehumidification units level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

9. Isolation Curb Support (for units mounted on isolation curbs): Install dehumidification units on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices. Flexible duct connectors are specified in Division 15 Section "Duct Accessories". Vibration isolation and seismic-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

C. Connections
1. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.
2. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.
3. Connect condensate drain pans using minimum NPS 1-1/4 (DN 32) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.
4. Refrigerant Piping: Comply with requirements in Division 15 Section "Refrigerant Piping". Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.
5. Hot-Water Piping: Comply with requirements in Division 15 Section "Hydronic Piping". Connect to supply coil tappings with shutoff valve, return coil tappings with balancing valve, and union or flange at each connection.
6. Steam and Condensate Piping: Comply with requirements in Division 15 Section "Steam And Condensate Piping". Connect with shutoff valve and union or flange.
7. Duct installation requirements are specified in other Division 15. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
   a. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure and insulate the space between roof and bottom of dehumidification unit.

D. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
   b. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
   c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Dehumidification unit will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

E. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
2. Perform the following final checks before startup:
   a. Verify that shipping, blocking, and bracing are removed.
   b. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   c. Perform cleaning and adjusting specified in this Section.
   d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
   e. Check lubrication of bearings, pulleys, belts, and other moving parts.
   f. Set outside- and return-air mixing dampers to minimum outside-air setting.
   g. Install clean filters.
   h. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

3. Starting procedures for dehumidification units include the following:
   a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
   b. Measure and record motor's electrical values for voltage and amperage.
   c. Manually operate dampers from fully closed to fully open position and record fan performance.
4. Comply with requirements in Division 15 Section "Testing, Adjusting, And Balancing" for testing, adjusting, and balancing of dehumidification unit.
5. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

F. Adjusting
1. Adjust damper linkages for proper damper operation.
2. Adjust initial temperature and humidity set points.

G. Cleaning
1. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
2. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

H. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

END OF SECTION 15785

Task	Specification	Specification Description
15785	01352	No Specification Required

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SECTION 15811 - FURNACES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for furnaces. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Gas-fired, noncondensing, Gas-fired, condensing, Oil-fired, and Electric furnaces and accessories complete with controls.
b. Air filters.
c. Air cleaners.
d. Ultraviolet germicidal lights.
e. Humidifiers.
f. Ventilation heat exchangers.
g. Refrigeration components.

C. Submittals
1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each of the following:
a. Furnace.
b. Thermostat.
c. Humidistat.
d. Air filter.
e. Air cleaner.
f. Ultraviolet germicidal light.
g. Humidifier.
h. Ventilation heat exchanger.
i. Refrigeration components.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
a. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and maintenance data.
4. LEED Submittals:
a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
c. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
5. Warranty: Special warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. Comply with NFPA 70.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
   a. Warranty Period, Commencing on Date of Substantial Completion:
      1) Furnace Heat Exchanger: 10 years **OR** 20 years **OR** Lifetime, **as directed**.
      2) Integrated Ignition and Blower Control Circuit Board: Five years.
      3) Draft-Inducer Motor: Five years.
      4) High-Efficiency Oil Furnace Burner: Three years.
      5) Refrigeration Compressors: 10 years **OR** Lifetime, **as directed**.
      6) Evaporator and Condenser Coils: Five years.

1.2 PRODUCTS

A. Gas-Fired Furnaces, Noncondensing
1. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
   a. Cabinet interior around heat exchanger shall be factory-installed insulation.
   b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
   c. Factory paint external cabinets in manufacturer's standard color.
   d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive **OR** belt drive **OR** direct or belt drive **OR** drive type indicated on Drawings, **as directed**.
   a. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 15 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.
      OR
      Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
      OR
      Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
4. Type of Gas: Natural **OR** Propane, **as directed**.
5. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
6. Burner:
   a. Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
   b. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
7. Gas-Burner Safety Controls:
   a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
   b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
   c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

8. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
9. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
10. Vent Materials: Comply with requirements in Division 15 Section "Breechings, Chimneys, And Stacks", for Type B metal vents.

B. Gas-Fired Furnaces, Condensing
1. General Requirements for Gas-Fired, Condensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
   a. Cabinet interior around heat exchanger shall be factory-installed insulation.
   b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
   c. Factory paint external cabinets in manufacturer's standard color.
   d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
   a. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 15 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.
      OR
      Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
      OR
      Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
4. Type of Gas: Natural **OR** Propane, **as directed**.
5. Heat Exchanger:
   a. Primary: Aluminized **OR** Stainless, **as directed**, steel.
   b. Secondary: Polyethylene-coated **OR** Stainless, **as directed**, steel.
6. Burner:
   a. Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
   b. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
7. Gas-Burner Safety Controls:
   a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
   b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
   c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
8. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
9. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories; diagnostic light with viewport, **as directed**.
10. Accessories:
    a. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through outside wall **OR** roof, **as directed**.
    b. CPVC Plastic Vent Materials.
       1) CPVC Plastic Pipe: Schedule 40, complying with ASTM F 441/F 441M.

2) CPVC Plastic Fittings: Schedule 40, complying with ASTM F 438, socket type.
3) CPVC Solvent Cement: ASTM F 493.
a) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

c. PVC Plastic Vent Materials:
1) PVC Plastic Pipe: Schedule 40, complying with ASTM D 1785.
2) PVC Plastic Fittings: Schedule 40, complying with ASTM D 2466, socket type.
3) PVC Solvent Cement: ASTM D 2564.
a) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Oil-Fired Furnaces
1. General Requirements for Oil-Fired Furnaces: Factory assembled, piped, wired, and tested; complying with UL 727 and with NFPA 31.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
a. Cabinet interior around heat exchanger shall be factory-installed insulation.
b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
c. Factory paint external cabinets in manufacturer's standard color.
d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive **OR** belt drive **OR** drive type indicated on Drawings, **as directed**.
a. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
4. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 15 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.
OR
Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
5. Heat Exchanger: Welded steel with ceramic-fiber liner **OR** refractory insert, **as directed**, at the burner in the combustion chamber. Minimum 2-inch- (50-mm-) diameter access ports in heat exchanger to permit access for cleaning.
6. Burner: High-pressure atomizing type, with rubber-mounted, adjustable, combustion-air blower; integrated fuel pump; hinged, flame-inspection port; cadmium-sulfide flame sensor; electrodes; ignition transformer; and oil nozzle.
a. Time-Delay Relay: Limits time for establishing main flame.
b. Flame Sensor: Monitors flame and stops burner on flame failure.
c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
7. Barometric Draft Regulator: Match furnace; for mounting in flue.
8. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
9. Vent Materials: Comply with requirements in Division 15 Section "Breechings, Chimneys, And Stacks" for Type B metal vents.

D. Electric Furnaces
1. General Requirements for Electric Furnaces: Factory assembled, piped, wired, and tested.
2. Cabinet: Steel, with duct liner downstream from cooling coil, **as directed**.
a. Duct Liner: Fiberglass, minimum 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, thick, complying with ASTM C 1071 and having a coated surface exposed to airstream

complying with NFPA 90A or NFPA 90B and with NAIMA's "Fibrous Glass Duct Liner Standard."

1) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

b. Factory paint external cabinets in manufacturer's standard color.

3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.

a. Fan Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 15 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.

OR

Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

OR

Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.

4. Electric-Resistant Heating Elements: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports.

5. Heating-Element Control: Sequencer relay with relay for each element; switches elements on and off, with delay between each increment; initiates, stops, or changes fan speed.

6. Summer Fan Switch: Connected to permit independent on-off switch of unit fan.

E. Thermostats And Humidistats

1. Solid-State Thermostat: Wall-mounting **OR** Freestanding **OR** Wireless, **as directed**, programmable, microprocessor-based unit with automatic **OR** manual, **as directed**, switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, **as directed**, and battery backup protection against power failure for program settings.

OR

Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounting unit with fan on-automatic selector.

OR

Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounting unit with fan on-automatic selector.

OR

Single-Stage **OR** Two-Stage, **as directed**, Heating-Only Thermostat: Wall-mounting unit with fan on-automatic selector.

OR

Solid-State, Combination Thermostat and Humidistat: Wall-mounting **OR** Freestanding **OR** Wireless, **as directed**, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, **as directed**, and battery backup protection against power failure for program settings.

2. Humidistat: Adjustable, wall-mounting **OR** duct-mounting, **as directed**, unit.

3. Control Wiring: Unshielded twisted-pair cabling.

a. No. 24 AWG, 100 ohm, four pair.

b. Cable Jacket Color: Blue.

4. Controls shall comply with requirements in ASHRAE/IESNA 90.1-2004, "Controls."

F. Air Filters

1. Washable Filters: 1-inch- (25-mm-) thick, urethane pad.

2. Disposable Filters: 1-inch- (25-mm-) thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**, in sheet metal frame.

3. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace, generates electrostatic charge; MERV 10 rating.

4. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter, high-efficiency particulate air (HEPA) disposable filter, and carbon VOC, **as directed**. HEPA shall be as follows:
   a. Standard: UL 586, "High-Efficiency, Particulate, Air Filter Units."
   b. Rating: ASHRAE 52.1, dust-spot efficiency of 65 percent; ASHRAE 52.2, 99.97 percent efficiency to 0.03-micrometer particle size.

G. Air Cleaners
1. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.
   a. Standard: UL 586, "High-Efficiency, Particulate, Air Filter Units."
   b. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
   c. Static Pressure Drop: Maximum 0.14-inch wg (35 Pa) at 300-fpm (1.52-m/s) air velocity.

H. Ultraviolet Germicidal Lights
1. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with one **OR** two, **as directed**, 75-W ultraviolet-light bulb(s).

I. Humidifiers
1. Minimum capacity rating indicated according to ARI 610, "Central System Humidifiers for Residential Applications."
2. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.
   OR
   Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.
   OR
   Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.
   OR
   Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.
   OR
   Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.
3. Comply with applicable requirements in ASHRAE 62.1-2004.

J. Ventilation Air Heat Exchanger
1. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.
2. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.
3. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
4. Filters: 1-inch- (25-mm-) thick disposable type with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**, in galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.
5. Wiring: Wire motors and controls so only external connections are required during installation.

K. Refrigeration Components
1. General Refrigeration Component Requirements:

a. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
b. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment." Match size with furnace. Include condensate drain pan with accessible drain outlet complying with ASHRAE 62.1-2004, **as directed**.
   a. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.
3. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.
   a. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I, 1/2 inch (13 mm) **OR** 1 inch (25 mm), **as directed**, thick.
4. Refrigerant Piping: Comply with requirements in Division 15 Section "Refrigerant Piping".
5. Air-Cooled, Compressor-Condenser Unit:
   a. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
   b. Compressor: Hermetically sealed reciprocating **OR** scroll, **as directed**, type.
      1) Crankcase heater.
      2) Restrained vibration **OR** Vibration, **as directed**, isolation mounts for compressor.
      3) Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
      4) Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
      5) Refrigerant Charge: R-22 **OR** R-407C **OR** R-410A, **as directed**.
   c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
   d. Heat-Pump Components: Reversing valve and low-temperature air cut-off thermostat.
   e. Fan: Aluminum-propeller type, directly connected to motor.
   f. Motor: Permanently lubricated, with integral thermal-overload protection.
   g. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
   h. Mounting Base: Polyethylene.

1.3 EXECUTION

A. Installation
1. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.
2. Install oil-fired furnaces and associated fuel and vent piping according to NFPA 31.
3. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
   a. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.
4. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
   a. Anchor furnace to substrate to resist code-required seismic acceleration.
5. Controls: Install thermostats and humidistats at mounting height of 60 inches (1500 mm) above floor.
6. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.

7. Install ground-mounted, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete". Coordinate anchor installation with concrete base.
   OR
   Install ground-mounted, compressor-condenser components on polyethylene mounting base.
8. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories". Anchor units to supports with removable, cadmium-plated fasteners.

B. Connections
1. Gas piping installation requirements are specified in Division 15 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.
2. Oil piping installation requirements are specified in Division 15 Section "Facility Fuel-oil Piping". Drawings indicate general arrangement of piping, fittings, and specialties. Connect oil piping with union or flange and ball **OR** gate, **as directed**, valve.
3. Install piping adjacent to equipment to allow service and maintenance.
4. Water piping installation requirements for furnaces with humidifiers are specified in Division 15 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.
5. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Division 15 Section "Breechings, Chimneys, And Stacks".
6. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.
   a. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
   b. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
   c. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
      1) Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
      2) CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
      3) PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
      4) Requirements for Low-Emitting Materials:
         a) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
         b) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
         c) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   d. Slope pipe vent back to furnace or to outside terminal.
7. Vent Connections, Oil-Fired Furnaces: Connect Type L vents to furnace vent connection and extend outdoors. Type L vents and their installation requirements are specified in Division 15 Section "Breechings, Chimneys, And Stacks".
8. Connect ducts to furnace with flexible connector. Comply with requirements in Division 15 Section "Duct Accessories".
9. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.

a. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."
OR
Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
OR
Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

10. Comply with requirements in Division 15 Section "Refrigerant Piping" for installation and joint construction of refrigerant piping.

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Perform electrical test and visual and mechanical inspection.
   b. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
   d. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
   e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.

D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
   a. Inspect for physical damage to unit casings.
   b. Verify that access doors move freely and are weathertight.
   c. Clean units and inspect for construction debris.
   d. Verify that all bolts and screws are tight.
   e. Adjust vibration isolation and flexible connections.
   f. Verify that controls are connected and operational.
2. Adjust fan belts to proper alignment and tension.
3. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.
4. Measure and record airflows.
5. Verify proper operation of capacity control device.
6. After startup and performance test, lubricate bearings and adjust belt tension, **as directed**.

E. Adjusting
1. Adjust initial temperature and humidity set points.
2. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.

F. Cleaning
1. After completing installation, clean furnaces internally according to manufacturer's written instructions.
2. Install new filters in each furnace within 14 days after Substantial Completion.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.

END OF SECTION 15811

Task	Specification	Specification Description
15816	15770d	Unit Ventilators
15820	15811	Furnaces

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SECTION 15821 - CENTRIFUGAL FANS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for centrifugal fans. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Airfoil centrifugal fans.
b. Backward-inclined centrifugal fans.
c. Forward-curved centrifugal fans.
d. Plenum fans.
e. Plug fans.

C. Performance Requirements
1. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
2. Operating Limits: Classify according to AMCA 99.

D. Submittals
1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

F. Delivery, Storage, And Handling
1. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

1.2 PRODUCTS

A. Airfoil Centrifugal Fans
1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, **as directed,**, drive assembly, and support structure.

2. Housings: Formed panels to make curved-scroll housings with shaped cutoff, with doors or panels to allow access to internal parts and components.
   a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
   b. Horizontally split, bolted-flange housing.
   c. Spun inlet cone with flange.
   d. Outlet flange.
3. Airfoil Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating, **as directed**.
4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
   b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
   f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:
   a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
   b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed,** gasketed door allowing access to fan scroll, of same material as housing.
   c. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
   d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
   f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed,** blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.

g. Inlet Screens: Grid screen of same material as housing.
h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
i. Spark-Resistant Construction: AMCA 99.
j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

10. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
    a. Enclosure Type: Totally enclosed, fan cooled.

B. Backward-Inclined Centrifugal Fans
1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.
2. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
    a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
    b. Spun inlet cone with flange.
    c. Outlet flange.
3. Backward-Inclined Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate, **as directed**, and fastened to shaft with set screws.
4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
    a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
    a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
    b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
    a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
    b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
    a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
    b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
    a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**].
    b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
    c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
    e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
    f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:

a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed,** gasketed door allowing access to fan scroll, of same material as housing.
c. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed,** blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
g. Inlet Screens: Grid screen of same material as housing.
h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
i. Spark-Resistant Construction: AMCA 99.
j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

10. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
    a. Enclosure Type: Totally enclosed, fan cooled.

C. Forward-Curved Centrifugal Fans
1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
    a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
    b. Horizontally split, bolted-flange housing.
    c. Spun inlet cone with flange.
    d. Outlet flange.
3. Forward-Curved Wheels: Black-enameled or galvanized steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
    a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
    b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
    a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
    b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
    a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
    b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
    a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
    b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.

8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.5.
   b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
   f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:
   a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
   b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed,** gasketed door allowing access to fan scroll, of same material as housing.
   c. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
   d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
   f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed,** blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
   g. Inlet Screens: Grid screen of same material as housing.
   h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
   i. Spark-Resistant Construction: AMCA 99.
   j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
   k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
10. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Enclosure Type: Totally enclosed, fan cooled.

D. Plenum Fans
1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating.
3. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
5. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.

6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
   b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
   c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
   f. Motor Mount: Adjustable for belt tensioning.
8. Accessories:
   a. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
   b. Spark-Resistant Construction: AMCA 99.
   c. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Enclosure Type: Totally enclosed, fan cooled.

E. Plug Fans
1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating, **as directed**.
3. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
   b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
5. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
   a. Ball-Bearing Rating Life: ABMA 9, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
   b. Roller-Bearing Rating Life: ABMA 11, Ll0 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
f. Motor Mount: Adjustable for belt tensioning.

8. Accessories:
a. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
b. Spark-Resistant Construction: AMCA 99.
c. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

9. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
a. Enclosure Type: Totally enclosed, fan cooled.

F. Source Quality Control
1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

1.3 EXECUTION

A. Installation
1. Install centrifugal fans level and plumb.
2. Support floor-mounting units using spring isolators **OR** restrained spring isolators, **as directed,** having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed,** having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install units with clearances for service and maintenance.
7. Label fans according to requirements specified in Division 15 Section "Identification For Hvac Piping And Equipment".

B. Connections
1. Duct installation and connection requirements are specified in other Division 15. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories".

2. Install ducts adjacent to fans to allow service and maintenance.
3. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.
4. Ground equipment according to Division 16 Section "Grounding And Bonding".
5. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Verify that shipping, blocking, and bracing are removed.
   b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   c. Verify that cleaning and adjusting are complete.
   d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   e. Adjust belt tension.
   f. Adjust damper linkages for proper damper operation.
   g. Verify lubrication for bearings and other moving parts.
   h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   i. Refer to Division 15 Section "Testing, Adjusting, And Balancing" for testing, adjusting, and balancing procedures.
   j. Remove and replace malfunctioning units and retest as specified above.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 15821

Task	Specification	Specification Description
15821	01352	No Specification Required

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SECTION 15826 - AIR CURTAINS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for air curtains. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes air curtains with hot-water heat, steam heat, electric heat, and gas-fired heater.

C. Submittals
1. Product Data: Include rated capacities, furnished specialties, and accessories for each unit indicated.
2. Shop Drawings:
   a. Include plans, elevations, sections, details, and attachments to other work.
   b. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with AMCA 220, "Test Methods for Air Curtain Units," for airflow, outlet velocity, and power consumption.
3. Comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.
   a. Certify coils according to ARI 410.
4. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.
   a. Warranty Period (Nonheating Units): Five years **OR** Two years **OR** One year, **as directed**.
   b. Warranty Period (Water or Steam Heating Units): Five years **OR** Two years **OR** One year, **as directed**.
   c. Warranty Period (Gas Heating Units): One year.

1.2 PRODUCTS

A. Materials
1. Housing Materials: Galvanized steel with electrostatically applied epoxy enamel finish over powdered mirror **OR** One-piece, molded, high-impact, white polymer material **OR** Heavy-gage, electroplated-zinc steel with welded construction and polyester-coated finish **OR** Heavy-gage, aluminum construction, Class II clear **OR** color, **as directed**, anodized finish, **as directed**.
2. Intake Louvers: Integral part of the housing, mechanically field adjustable and capable of reducing air-outlet velocity by 60 percent with louver in totally closed position.
3. Discharge Nozzle: Integral part of the housing, containing adjustable air-directional vanes.

B. Fans
1. Fans: Galvanized steel **OR** Painted steel **OR** Aluminum, **as directed**, Centrifugal, forward curved, double width, double inlet **OR** Vane axial, statically and dynamically balanced, **as directed**.
2. Fan Drives: Direct **OR** Belt, equipped with belt guards and adjustable sheaves and pulleys for adjusting air-outlet velocity, **as directed**.

C. Motors
1. Motor Type: Two speed **OR** Multispeed, **as directed**, resiliently mounted, continuous duty, totally enclosed, air over **OR** totally enclosed, fan cooled, **OR**, open, dripproof **OR** explosion proof, **as directed**, with integral thermal-overload protection, **as directed**.
2. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
3. Disconnect: Internal power cord with plug and receptacle.

D. Water Coils
1. Description: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil.
   a. Piping Connections: Threaded on same end **OR** opposite ends, **as directed**.
2. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
3. Fins: Aluminum **OR** Copper, **as directed**.
4. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
5. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
6. Frames: Galvanized-steel channel frame.
7. Ratings: According to ASHRAE 33.
   a. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).
8. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.

E. Steam Coils
1. Description: Distribution header coil, with threaded steam supply and condensate connections.
   a. Connections: Same end **OR** Opposite ends **OR** Steam supply on both ends; condensate on one end, **as directed**.
2. Tubes: Copper, complying with ASTM B 75 (ASTM B 75M).
   a. Tube Diameter: 0.625 inch (15.9 mm).
3. Fins: Aluminum **OR** Copper, **as directed**.
4. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
5. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
6. Frames: Galvanized-steel channel frame.
7. Ratings: According to ASHRAE 33.
   a. Working-Pressure Ratings: 100 psig (690 kPa), 400 deg F (205 deg C).
8. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.

F. Electric Heating Coils
1. Coil Assembly: Comply with UL 1995.
2. Frame: Galvanized-steel frame.
3. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath **OR** Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame, **as directed**.
4. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.

a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

5. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection. Include the following controls:
   a. Magnetic contactor.
   b. Mercury contactor.
   c. Solid-state stepless pulse controller.
   d. Toggle switches; one per step.
   e. Step controller.
   f. Time-delay relay.
   g. Pilot lights; one per step.
   h. Airflow proving switch.

G. Gas-Fired Heaters
1. Comply with AGA Z83.8, "Gas Unit Heaters."
   a. AGA Approval: Bear AGA label.
   b. Type of Gas: Natural **OR** LP, **as directed**.
2. Assembly and Wiring: Heaters factory assembled, piped, wired, and tested for 120-V ac.
3. Housing: Steel, with integral draft hood and inserts for suspension-mounting rods.
   a. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
4. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
5. Burners: Cast iron or aluminized steel with stainless-steel inserts.
6. Venting Provision: Gravity.
7. Power Venter: 120-V ac, with stainless-steel shaft.
8. Automatic Gas Control: Single-stage **OR** 2-stage, **as directed**, 24-V ac valve.
9. Ignition: Standing pilot **OR** Electronically controlled spark with flame sensor, **as directed**.

H. Filters
1. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in cardboard **OR** galvanized-steel, **as directed**, frame.
2. Washable Panel Filters: Removable, stainless-steel, baffle-type filters with spring-loaded fastening; with minimum 0.0781-inch- (1.984-mm-) thick, stainless-steel filter frame.
3. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

I. Accessories
1. Built-in **OR** Field-Installed, **as directed**, Thermostat: Line voltage, factory installed and wired to the junction box on air curtain.
2. Automatic Door Switch: Plunger type installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes.
3. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
4. Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.
5. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, Type 1 **OR** 12, **as directed**, enclosure.
6. Mounting Brackets: Adjustable mounting brackets for drum-type roll-up doors.

1.3 EXECUTION

A. Installation
1. Install air curtains with clearance for equipment service and maintenance.

B. Connections
1. Install piping adjacent to air curtain to allow service and maintenance.

2. Breaching: Comply with applicable requirements in Division 15 Section "Breechings, Chimneys, And Stacks". Connect breaching to full size at flue outlet.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. After installing air curtains completely, perform visual and mechanical check of individual components.
   b. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
   c. Test gas train and verify that there are no gas leaks.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Repair or replace malfunctioning units and retest as specified above.

END OF SECTION 15826

SECTION 15827 - AXIAL FANS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for axial fans. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Tubeaxial fans.
b. Vaneaxial fans.
c. Mixed-flow fans.

C. Performance Requirements
1. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
2. Operating Limits: Classify according to AMCA 99.

D. Submittals
1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
a. Certified fan performance curves with system operating conditions indicated.
b. Certified fan sound-power ratings.
c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
d. Material thickness and finishes, including color charts.
e. Dampers, including housings, linkages, and operators.
f. Fan speed controllers.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
a. Wiring Diagrams: Power, signal, and control wiring.
b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
c. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
3. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

F. Delivery, Storage, And Handling

1. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

G. Coordination
1. Coordinate size and location of structural-steel support members.
2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 02..
3. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories".

1.2 PRODUCTS

A. Tubeaxial Fans
1. Description: Fan wheel and housing, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
2. Housings: Steel **OR** Galvanized steel **OR** Aluminum **OR** Fiberglass-reinforced plastic **OR** Stainless steel, **as directed,** with flanged inlet and outlet connections.
3. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key **OR** Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft **OR** Cast aluminum, machined and fitted to shaft, **as directed**.
4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
   b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   f. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
   g. Motor Mount: Adjustable base.
   h. Shaft Bearings: Radial, self-aligning ball or roller bearings.
      1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
         OR
         Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
      2) Extend lubrication lines to outside of casing and terminate with grease fittings.
5. Accessories:
   a. Companion Flanges: Rolled flanges of same material as housing.
   b. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
   c. Propeller Access Section Door: Short duct section bolted to fan inlet **OR** outlet **OR** inlet and outlet, **as directed,** allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
   d. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
   e. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed,** clips welded to fan housing, of same material as housing.
   f. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
   g. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.

h. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
i. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
j. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (149 deg C).
k. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
l. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
m. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing **OR** aluminum, **as directed**.
n. Inlet Cones: Round-to-round transition of same material as housing.
o. Outlet Cones: Round-to-round transition of same material as housing.
p. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

6. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
   b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing, **as directed**.
7. Factory Finishes:
   a. Sheet Metal Parts: Prime coat before final assembly.
   b. Exterior Surfaces: Baked-enamel finish coat after assembly.
   c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
      1) Apply to finished housings.
      2) Apply to fan wheels.

B. Vaneaxial Fans
1. Description: Fan wheel and housing, straightening vane section**,** factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
   a. Variable-Pitch Fans: Internally mounted pneumatic **OR** electric **OR** electronic, **as directed,** actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.
2. Housings: Steel **OR** Galvanized steel **OR** Aluminum **OR** Fiberglass-reinforced plastic **OR** Stainless steel, **as directed**.
   a. Inlet and Outlet Connections: Flanges.
   b. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
3. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key **OR** Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft **OR** Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced, **as directed**.
4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
   b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

f. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
g. Motor Mount: Adjustable base.
h. Shaft Bearings: Radial, self-aligning ball or roller bearings.
1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
OR
Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
2) Extend lubrication lines to outside of casing and terminate with grease fittings.

5. Accessories:
a. Companion Flanges: Rolled flanges of same material as housing.
b. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
c. Propeller Access Section Door: Short duct section bolted to fan inlet **OR** outlet **OR** inlet and outlet, **as directed,** allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
d. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
e. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
f. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
g. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
h. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
i. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
j. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
k. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Division 15 Section(s) "Hvac Instrumentation And Controls" AND "Sequence Of Operation".
l. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to300 deg F (148 deg C).
m. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
n. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
o. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
p. Inlet Cones: Round-to-round transition of same material as housing.
q. Outlet Cones: Round-to-round transition of same material as housing.
r. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.

6. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing, **as directed**.

7. Factory Finishes:
a. Sheet Metal Parts: Prime coat before final assembly.
b. Exterior Surfaces: Baked-enamel finish coat after assembly.
c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.

1) Apply to finished housings.
2) Apply to fan wheels.

C. Mixed-Flow Fans
1. Description: Fan wheel and housing, straightening vane section, **as directed**, factory-mounted motor with belt drive, and accessories.
2. Housings: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**.
   a. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
   b. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
   c. Mixed-Flow Outlet Connection: One **OR** Two, **as directed,** flanged discharge(s) perpendicular to fan inlet.
3. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.
4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
   b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
   c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   f. Motor Mount: Adjustable base.
   g. Shaft Bearings: Radial, self-aligning ball or roller bearings.
      1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
         OR
         Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
      2) Extend lubrication lines to outside of casing and terminate with grease fittings.
5. Accessories:
   a. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed,** clips welded to fan housing, of same material as housing.
   b. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
   c. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
   d. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
   e. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
   f. Inlet Cones: Round-to-round transition of same material as housing.
   g. Outlet Cones: Round-to-round transition of same material as housing.
   h. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
6. Motors: Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
   b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.
7. Factory Finishes:
   a. Sheet Metal Parts: Prime coat before final assembly.
   b. Exterior Surfaces: Baked-enamel finish coat after assembly.
   c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
      1) Apply to finished housings.
      2) Apply to fan wheels.

D. Source Quality Control
1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

1.3 EXECUTION

A. Installation
1. Install axial fans level and plumb.
2. Support floor-mounting units using spring isolators **OR** restrained spring isolators, **as directed,** having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed,** having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install units with clearances for service and maintenance.
7. Label fans according to requirements specified in Division 15 Section "Identification For Hvac Piping And Equipment".

B. Connections
1. Duct installation and connection requirements are specified in other Division 15. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories".
2. Ground equipment according to Division 16 Section "Grounding And Bonding".
3. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. Verify that shipping, blocking, and bracing are removed.
   b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   c. Verify that cleaning and adjusting are complete.
   d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   e. Adjust belt tension.
   f. Adjust damper linkages for proper damper operation.
   g. Verify lubrication for bearings and other moving parts.
   h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

i. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
j. Shut unit down and reconnect automatic temperature-control operators.
k. Remove and replace malfunctioning units and retest as specified above.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Adjusting
1. Adjust damper linkages for proper damper operation.
2. Adjust belt tension.
3. Lubricate bearings.

END OF SECTION 15827

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SECTION 15828 - POWER VENTILATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for power ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Utility set fans.
b. Centrifugal roof ventilators.
c. Axial roof ventilators.
d. Upblast propeller roof exhaust fans.
e. Centrifugal wall ventilators.
f. Ceiling-mounting ventilators.
g. In-line centrifugal fans.
h. Propeller fans.

C. Performance Requirements
1. Project Altitude: Base fan-performance ratings on actual Project site elevations **OR** sea level, **as directed**.
2. Operating Limits: Classify according to AMCA 99.

D. Submittals
1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
4. UL Standard: Power ventilators shall comply with UL 705.

F. Delivery, Storage, And Handling
1. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

1.2 PRODUCTS

A. Utility Set Fans
1. Description: Direct **OR** Belt, **as directed,**-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
2. Housing: Fabricated of galvanized, **as directed**, steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
   a. Housing Discharge Arrangement: Adjustable to eight standard positions.
3. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
   a. Blade Materials: Steel **OR** Aluminum, **as directed**.
   b. Blade Type: Backward inclined **OR** Forward curved **OR** Airfoil, **as directed**.
   c. Spark-Resistant Construction: AMCA 99, Type A **OR** B **OR** C, **as directed**.
4. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
5. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L_{50} of 200,000 hours **OR** L_{10} of 80,000 hours, **as directed**.
6. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
   b. Motor Pulleys: Adjustable pitch for use with motors through 5, **as directed**, hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   c. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   d. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
7. Accessories:
   a. Inlet and Outlet: Flanged.
   b. Companion Flanges: Rolled flanges for duct connections of same material as housing.
   c. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
   d. Access Door: Gasketed door in scroll with latch-type handles.
   e. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
   f. Inlet Screens: Removable wire mesh.
   g. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
   h. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
   i. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed,** blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
   j. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
   k. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
8. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.

B. Centrifugal Roof Ventilators
1. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
2. Housing: Removable, spun-aluminum, dome top and outlet baffle **OR** extruded-aluminum, rectangular top **OR** galvanized steel, mushroom-domed top, **as directed**; square, one-piece, aluminum base with venturi inlet cone.
   a. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector, **as directed**.
   b. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

3. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
   a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   d. Fan and motor isolated from exhaust airstream.
5. Accessories:
   a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside **OR** outside, **as directed,** fan housing, factory wired through an internal aluminum conduit.
   c. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
   d. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   e. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
   a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
   b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
   c. Sound Curb: Curb with sound-absorbing insulation matrix.
   d. Pitch Mounting: Manufacture curb for roof slope.
   e. Metal Liner: Galvanized steel.
   f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed,** thick steel bars welded in place to form 6-inch (150-mm) squares.
   g. Mounting Pedestal: Galvanized steel with removable access panel.
   h. Vented Curb: Unlined with louvered vents in vertical sides.

C. Axial Roof Ventilators
1. Description: Direct- or belt-driven axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.
   a. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
3. Fan Wheel: Aluminum **OR** Steel, **as directed,** hub and blades.
4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
   a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Accessories:
   a. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside **OR** outside, **as directed,** fan housing, factory wired through an internal aluminum conduit.
   b. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
   c. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
   d. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
6. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
   a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.

b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
c. Sound Curb: Curb with sound-absorbing insulation matrix.
d. Pitch Mounting: Manufacture curb for roof slope.
e. Metal Liner: Galvanized steel.
f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed,** thick steel bars welded in place to form 6-inch (150-mm) squares.
g. Mounting Pedestal: Galvanized steel with removable access panel.

D. Upblast Propeller Roof Exhaust Fans
1. Description: Direct- or belt-driven propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
2. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel **OR** aluminum, **as directed**, containing galvanized-steel **OR** aluminum, **as directed,** butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
   a. Damper Rods: Steel with bronze **OR** nylon, **as directed,** bearings.
   b. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
3. Fan Wheel: Replaceable, cast **OR** extruded, **as directed,**-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
4. Belt-Driven Drive Assembly: Resiliently mounted to housing; weatherproof housing of same material as fan housing with the following features:
   a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   b. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
   c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   d. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.
5. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
   a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
   b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
   c. Sound Curb: Curb with sound-absorbing insulation matrix.
   d. Pitch Mounting: Manufacture curb for roof slope.
   e. Metal Liner: Galvanized steel.
   f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed,** thick steel bars welded in place to form 6-inch (150-mm) squares.
   g. Mounting Pedestal: Galvanized steel with removable access panel.

E. Centrifugal Wall Ventilators
1. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.
3. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
   a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
   c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
   d. Fan and motor isolated from exhaust airstream.
5. Accessories:
   a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
c. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
d. Wall Grille: Ring type for flush mounting.
e. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
f. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Ceiling-Mounting Ventilators
1. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.
2. Housing: Steel, lined with acoustical insulation.
3. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
4. Grille: Plastic **OR** Stainless steel **OR** Aluminum **OR** Painted aluminum, **as directed**, louvered grille with flange on intake and thumbscrew attachment to fan housing.
5. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
6. Accessories:
a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
b. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
c. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
d. Motion Sensor: Motion detector with adjustable shutoff timer.
e. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
f. Filter: Washable aluminum to fit between fan and grille.
g. Isolation: Rubber-in-shear vibration isolators.
h. Manufacturer's standard roof jack or wall cap, and transition fittings.

G. In-Line Centrifugal Fans
1. Description: In-line, direct **OR** belt, **as directed,**-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
2. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
3. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door, **as directed**.
4. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
5. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
6. Accessories:
a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
b. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
c. Companion Flanges: For inlet and outlet duct connections.
d. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
e. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

H. Propeller Fans
1. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.

2. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
3. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
4. Fan Wheel: Replaceable, cast **OR** extruded, **as directed,**-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
5. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
   a. Service Factor Based on Fan Motor Size: 1.4.
   b. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
   c. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
      1) Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.
   d. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
   e. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
   f. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
   g. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
6. Accessories:
   a. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
   b. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
   c. Wall Sleeve: Galvanized steel to match fan and accessory size.
   d. Weathershield Hood: Galvanized steel to match fan and accessory size.
   e. Weathershield Front Guard: Galvanized steel with expanded metal screen.
   f. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   g. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

I. Motors
1. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
2. Enclosure Type: Open dripproof **OR** Totally enclosed, fan cooled, **as directed**.

J. Source Quality Control
1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

1.3 EXECUTION

A. Installation
1. Install power ventilators level and plumb.
2. Support units using elastomeric mounts **OR** restrained elastomeric mounts **OR** spring isolators **OR** restrained spring isolators, **as directed,** having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

3. For projects not in seismic areas, install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. For projects in seismic areas, install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
6. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
7. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed,** having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
8. Install units with clearances for service and maintenance.
9. Label units according to requirements specified in Division 15 Section "Identification For Hvac Piping And Equipment".
10. Duct installation and connection requirements are specified in other Division 15. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories".
11. Install ducts adjacent to power ventilators to allow service and maintenance.
12. Ground equipment according to Division 16 Section "Grounding And Bonding".
13. Connect wiring according to Division 16 Section "Conductors And Cables".

B. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
   a. Verify that shipping, blocking, and bracing are removed.
   b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   c. Verify that cleaning and adjusting are complete.
   d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
   e. Adjust belt tension.
   f. Adjust damper linkages for proper damper operation.
   g. Verify lubrication for bearings and other moving parts.
   h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
   i. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
   j. Shut unit down and reconnect automatic temperature-control operators.
   k. Remove and replace malfunctioning units and retest as specified above.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 15828

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SECTION 15828a - INTAKE AND RELIEF VENTILATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for intake and relief ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Louvered-penthouse ventilators.
b. Roof hoods.
c. Goosenecks.

C. Performance Requirements
1. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural and seismic performance requirements and design criteria indicated.
2. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
a. Wind Loads: Determine loads based on pressures as indicated on Drawings.
OR
Wind Loads: Determine loads based on a uniform pressure of 20 lbf/sq. ft. (960 Pa) **OR** 30 lbf/sq. ft. (1440 Pa), **as directed**, acting inward or outward.
OR
Wind Loads: Determine loads based on pressures indicated below:
1) Corner Zone: Within <**Insert distance**> of building corners, uniform pressure of <**Insert design wind pressure**>, acting inward, and <**Insert design wind pressure**>, acting outward.
2) Other Than Corner Zone: Uniform pressure of <**Insert design wind pressure**>, acting inward, and <**Insert design wind pressure**>, acting outward.
3. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
4. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
a. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
5. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1-2004.

D. Submittals
1. Product Data: For each type of product indicated. For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
2. LEED Submittal:

a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."

3. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
   a. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.
4. Samples: For each exposed product and for each color and texture specified.
5. Delegated-Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
   a. Detail fabrication and assembly of shop-fabricated ventilators.
6. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   a. Structural members to which roof curbs and ventilators will be attached.
   b. Sizes and locations of roof openings.
7. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
8. Welding certificates.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
   a. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
   b. AWS D1.3, "Structural Welding Code - Sheet Steel."

F. Coordination
1. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.2 PRODUCTS

A. Materials
1. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.
2. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
3. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.
4. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. 4 **OR** 6, **as directed**, finish.
5. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.
   a. Use types and sizes to suit unit installation conditions.
   b. Use Phillips flat **OR** hex-head or Phillips pan, **as directed**,-head screws for exposed fasteners unless otherwise indicated.
6. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.
7. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

B. Fabrication, General
   1. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
   2. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
   3. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
   4. Fabricate supports, anchorages, and accessories required for complete assembly.
   5. Perform shop welding by AWS-certified procedures and personnel.

C. Louvered-Penthouse Ventilators
   1. Construction: All-welded assembly with 4-inch (100-mm) **OR** 6-inch (150-mm), **as directed**,-deep louvers, mitered corners, and aluminum **OR** galvanized-steel **OR** stainless-steel, **as directed**, sheet roof with mineral-fiber insulation and vapor barrier, **as directed**.
   2. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch (2.0 mm) for frames and 0.080 inch (2.0 mm) **OR** 0.060 inch (1.5 mm), **as directed**, for blades with condensate deflectors, **as directed**.
      a. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
      b. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** mitered blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
   3. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.052 inch (1.3 mm) for frames and 0.040 inch (1.0 mm) **OR** 0.052 inch (1.3 mm) **OR** 0.064 inch (1.6 mm), **as directed**, for blades with condensate deflectors, **as directed**.
      a. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
      b. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** mitered blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
   4. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.050 inch (1.27 mm) **OR** 0.062 inch (1.57 mm), **as directed**, with grain running parallel **OR** perpendicular, **as directed**, to length of blades and frame members with condensate deflectors, **as directed**.
      a. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
      b. Exterior Corners: Prefabricated corner units with mitered and welded blades **OR** mitered blades with concealed close-fitting splices, **as directed**, and with fully recessed **OR** semirecessed, **as directed**, mullions at corners.
   5. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.
      a. Configuration: Self-flashing without a cant strip, with **OR** Built-in cant and **OR** Built-in raised cant and, **as directed**, mounting flange.
      b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
   6. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire **OR** Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire **OR** Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick **OR** Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire, **as directed**.
      OR
      Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) **OR** Stainless-steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm), **as directed**, wire.
   7. Galvanized-Steel Sheet Finish:
      a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to

ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

8. Accessories:

a. Dampers:

1) Location: Penthouse neck **OR** Inside louver face, **as directed**.

2) Control: Manual **OR** Motorized, **as directed**.

D. Roof Hoods

1. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 5-6 and 5-7.

2. Materials: Galvanized-steel sheet, minimum 0.064-inch- (1.62-mm-) thick base and 0.040-inch- (1.0-mm-) thick hood **OR** Aluminum sheet, minimum 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood, **as directed**; suitably reinforced.

3. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

a. Configuration: Self-flashing without a cant strip, with **OR** Built-in cant and **OR** Built-in raised cant and, **as directed**, mounting flange.

b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.

4. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire **OR** Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire **OR** Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick **OR** Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire, **as directed**.

OR

Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) **OR** Stainless-steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm), **as directed**, wire.

5. Galvanized-Steel Sheet Finish:

a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

E. Goosenecks

1. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 5-5; with a minimum of 0.052-inch- (1.3-mm-) thick, galvanized-steel sheet.

2. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

a. Configuration: Self-flashing without a cant strip, with **OR** Built-in cant and **OR** Built-in raised cant and, **as directed**, mounting flange.
b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.

3. Bird Screening: Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire **OR** Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire **OR** Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick **OR** Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire, **as directed**.
OR
Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) **OR** Stainless-steel, 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm), **as directed**, wire.
4. Galvanized-Steel Sheet Finish:
a. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
b. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
c. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).
1) Color and Gloss: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

1.3 EXECUTION

A. Installation
1. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
2. Install goosenecks on curb base where throat size exceeds 9 by 9 inches (230 by 230 mm).
3. Install gravity ventilators with clearances for service and maintenance.
4. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
5. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.
6. Label gravity ventilators according to requirements specified in Division 15 Section "Identification For Hvac Piping And Equipment".
7. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
8. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

B. Connections
1. Duct installation and connection requirements are specified in other Division 15. Drawings indicate general arrangement of ducts and duct accessories.

C. Adjusting
1. Adjust damper linkages for proper damper operation.

END OF SECTION 15828a

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Task	Specification	Specification Description
15828	15770a	Packaged, Outdoor, Central-Station Air-Handling Units
15829	15828	Power Ventilators
15830	15828	Power Ventilators
15831	15828	Power Ventilators
15832	15828	Power Ventilators
15832	15828a	Intake and Relief Ventilators

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SECTION 15834 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for modular indoor central-station air-handling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Constant-air-volume, single-zone air-handling units.
b. Constant-air-volume, multizone air-handling units.
c. Constant-air-volume, dual-duct air-handling units.
d. Variable-air-volume, single-zone air-handling units.
e. Variable-air-volume, dual-duct air-handling units.

C. Performance Requirements
1. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 **OR** L/100, **as directed**, where "L" is the unsupported span length within completed casings.
3. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals
1. Product Data: For each air-handling unit indicated.
a. Unit dimensions and weight.
b. Cabinet material, metal thickness, finishes, insulation, and accessories.
c. Fans:
1) Certified fan-performance curves with system operating conditions indicated.
2) Certified fan-sound power ratings.
3) Fan construction and accessories.
4) Motor ratings, electrical characteristics, and motor accessories.
d. Certified coil-performance ratings with system operating conditions indicated.
e. Dampers, including housings, linkages, and operators.
f. Filters with performance characteristics.
2. LEED Submittal:
a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Delegated-Design Submittal: For vibration isolation and seismic restraints, **as directed**, indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.

4. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
3. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
4. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
5. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."
6. Comply with NFPA 70.

1.2 PRODUCTS

A. Unit Casings
1. General Fabrication Requirements for Casings:
   a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
   b. Casing Joints: Sheet metal screws or pop rivets.
   c. Sealing: Seal all joints with water-resistant sealant.
   d. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
      OR
      Factory Finish for Steel and Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.
      OR
      Casing Coating: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
   e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Casing Insulation and Adhesive:
   a. Materials: ASTM C 1071, Type I **OR** Type II, **as directed**.
   b. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.
      1) Liner Adhesive: Comply with ASTM C 916, Type I.
      2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.

3) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.

OR

Location and Application: Encased between outside and inside casing.

3. Inspection and Access Panels and Access Doors:
   a. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
   b. Inspection and Access Panels:
      1) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
      2) Gasket: Neoprene, applied around entire perimeters of panel frames.
      3) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
   c. Access Doors:
      1) Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
      2) Gasket: Neoprene, applied around entire perimeters of panel frames.
      3) Fabricate windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
      4) Size: At least 18 inches (450 mm) **OR** 24 inches (600 mm), **as directed**, wide by full height of unit casing up to a maximum height of 60 inches (1500 mm) **OR** 72 inches (1800 mm), **as directed**.
   d. Locations and Applications:
      1) Fan Section: Inspection and access panels **OR** Doors **OR** Doors and inspection and access panels, **as directed**.
      2) Access Section: Doors.
      3) Coil Section: Inspection and access panel.
      4) Damper Section: Inspection and access panels **OR** Doors, **as directed**.
      5) Filter Section: Inspection and access panels **OR** Doors, **as directed**, large enough to allow periodic removal and installation of filters.
      6) Mixing Section: Doors.
      7) Humidifier Section: Doors.
   e. Service Light: 100-W vaporproof fixture with switched junction box located outside **OR** inside, **as directed**, adjacent to door.
      1) Locations: Each section accessed with door **OR** Fan section, **as directed**.
4. Condensate Drain Pans:
   a. Fabricated with one **OR** two, **as directed**, percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
      1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-2004.
      2) Depth: A minimum of 2 inches (50 mm) deep.
   b. Formed sections **OR** Integral part of floor plating, **as directed**.
   c. Single-wall, galvanized-steel **OR** stainless-steel, **as directed**, sheet.

      OR

      Double-wall, galvanized-steel **OR** stainless-steel, **as directed**, sheet with space between walls filled with foam insulation and moisture-tight seal.
   d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end **OR** both ends, **as directed**, of pan.
      1) Minimum Connection Size: NPS 1 (DN 25) **OR** NPS 2 (DN 50), **as directed**.
   e. Pan-Top Surface Coating: Asphaltic waterproofing compound, for galvanized-steel drain pans.

f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

5. Service Platform: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.

6. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when air-handling unit frame is anchored to building structure.

B. Fan, Drive, And Motor Section

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.

a. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

1) Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.

2) Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

2. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.

b. Horizontal-Flanged, Split Housing: Bolted construction.

c. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.

d. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) **OR** 5-3/4 inches (146 mm), **as directed**, wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick aluminum sheets; select metal compatible with casing.

1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.

a) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).

b) Fabric Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.

c) Fabric Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

3. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.

4. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

OR

Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

OR

Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

OR

Axial Fans: Fan wheel and housing, straightening-vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

a. Variable-Pitch Fans: Internally mounted pneumatic **OR** electric **OR** electronic, **as directed**, actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.

b. Housings: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**.

1) Inlet and Outlet Connections: Flanges.

2) Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.

5. Fan Shaft Bearings:

a. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 50,000 **OR** 120,000, **as directed**, hours according to ABMA 9.

OR

Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing with grease lines extended to outside unit, **as directed**, and a rated life of 50,000 **OR** 120,000, **as directed**, hours according to ABMA 11.

OR

Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit, **as directed**.

6. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**, service factor based on fan motor.

a. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

b. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.

c. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.

d. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.

7. Variable-Inlet Vanes: Steel, with blades supported at both ends with permanently lubricated bearings. Variable mechanism terminating in single lever for connection to control actuator with connecting shaft for second set of variable inlet vanes on double-width fans.

OR

Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed **OR** parallel, **as directed**, blades constructed of two plates formed around and welded to shaft, with blades linked out of air stream to single control lever.

8. Internal Vibration Isolation and Seismic Control, **as directed**: Fans shall be factory mounted with manufacturer's standard restrained, **as directed**, vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.

a. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.

9. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

a. Enclosure Type: Totally enclosed, fan cooled.

b. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.

c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.
e. Mount unit-mounted disconnect switches on exterior **OR** interior, **as directed**, of unit.

10. Variable Frequency Controllers:
    a. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
    b. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes **OR** 120 Hz, with horsepower constant throughout speed range, **as directed**.
    c. Unit Operating Requirements:
        1) Input ac voltage tolerance of 208 V, plus or minus 5 **OR** 380 to 500 V, plus or minus 10 **OR** 525 to 575 V, plus or minus 10, **as directed**, percent.
        2) Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
        3) Minimum Efficiency: 96 percent at 60 Hz, full load.
        4) Minimum Displacement Primary-Side Power Factor: 96 percent.
        5) Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
        6) Starting Torque: 100 percent of rated torque or as indicated.
        7) Speed Regulation: Plus or minus 1 percent.
    d. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
    e. Internal Adjustability Capabilities:
        1) Minimum Speed: 5 to 25 percent of maximum rpm.
        2) Maximum Speed: 80 to 100 percent of maximum rpm.
        3) Acceleration: 2 to a minimum of 22 seconds.
        4) Deceleration: 2 to a minimum of 22 seconds.
        5) Current Limit: 50 to a minimum of 110 percent of maximum rating.
    f. Self-Protection and Reliability Features:
        1) Input transient protection by means of surge suppressors.
        2) Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
        3) Adjustable motor overload relays capable of NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, performance.
        4) Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
        5) Instantaneous line-to-line and line-to-ground overcurrent trips.
        6) Loss-of-phase protection.
        7) Reverse-phase protection.
        8) Short-circuit protection.
        9) Motor overtemperature fault.
    g. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
    h. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
    i. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
    j. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
    k. Door-mounted LED status lights shall indicate the following conditions:
        1) Power on.

2) Run.
3) Overvoltage.
4) Line fault.
5) Overcurrent.
6) External fault.

l. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed time meter.

m. Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1) Output frequency (Hertz).
2) Motor speed (rpm).
3) Motor status (running, stop, fault).
4) Motor current (amperes).
5) Motor torque (percent).
6) Fault or alarming status (code).
7) Proportional-integral-derivative (PID) feedback signal (percent).
8) DC-link voltage (volts direct current).
9) Set-point frequency (Hertz).
10) Motor output voltage (volts).

n. Control Signal Interface:
1) Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2) Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:
a) 0 to 10-V dc.
b) 0-20 or 4-20 mA.
c) Potentiometer using up/down digital inputs.
d) Fixed frequencies using digital inputs.
e) RS485.
f) Keypad display for local hand operation.
3) Output signal interface with a minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
a) Output frequency (Hertz).
b) Output current (load).
c) DC-link voltage (volts direct current).
d) Motor torque (percent).
e) Motor speed (rpm).
f) Set-point frequency (Hertz).
4) Remote indication interface with a minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
a) Motor running.
b) Set-point speed reached.
c) Fault and warning indication (overtemperature or overcurrent).
d) High- or low-speed limits reached.

o. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

p. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch **OR** NEMA KS 1, nonfusible switch **OR** NEMA KS 1, fusible switch, **as directed**, with lockable handle.

q. Accessories:
1) Devices shall be factory installed in controller enclosure unless otherwise indicated.
2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
3) Standard Displays:

a) Output frequency (Hertz).
b) Set-point frequency (Hertz).
c) Motor current (amperes).
d) DC-link voltage (volts direct current).
e) Motor torque (percent).
f) Motor speed (rpm).
g) Motor output voltage (volts).

C. Coil Section
1. General Requirements for Coil Section:
a. Comply with ARI 410.
b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
d. Coils shall not act as structural component of unit.
e. Seismic Fabrication Requirements: Fabricate coil section, internal mounting frame and attachment to coils, and other coil section components with reinforcement strong enough to withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when coil-mounting frame and air-handling-unit mounting frame are anchored to building structure.
2. Electrical Heating Coils, Controls, and Accessories: Comply with UL 1995.
a. Casing Assembly: Slip-in **OR** Flanged, **as directed**, type with galvanized-steel frame.
b. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
OR
Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
e. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection.
1) Magnetic **OR** Mercury, **as directed**, contactor.
2) Solid-state, stepless pulse controller.
3) Toggle switches, one per step.
4) Step controller.
5) Time-delay relay.
6) Pilot lights, one per step.
7) Airflow proving switch.

D. Air Filtration Section
1. General Requirements for Air Filtration Section:
a. Comply with NFPA 90A.
b. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
c. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.
2. Disposable Panel Filters:
a. Factory-fabricated, viscous-coated, flat-panel type.
b. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
c. Dust-Holding Capacity: as directed by the Owner.

d. Initial Resistance: as directed by the Owner.
e. Recommended Final Resistance: as directed by the Owner.
f. Arrestance (ASHRAE 52.1): 80.
g. Merv (ASHRAE 52.2): 5.
h. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
i. Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.

3. Extended-Surface, Disposable Panel Filters:
   a. Factory-fabricated, dry, extended-surface type.
   b. Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
   c. Dust-Holding Capacity: as directed by the Owner.
   d. Initial Resistance: as directed by the Owner.
   e. Recommended Final Resistance: as directed by the Owner.
   f. Arrestance (ASHRAE 52.1): 90.
   g. Merv (ASHRAE 52.2): 7.
   h. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
   i. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, 3/4-inch (20-mm) particleboard with gaskets, **as directed**.
   j. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks.
4. Extended-Surface, Nonsupported-Media Filters:
   a. Factory-fabricated, dry, extended-surface, self-supporting type.
   b. Dust-Holding Capacity: as directed by the Owner.
   c. Initial Resistance: as directed by the Owner.
   d. Recommended Final Resistance: as directed by the Owner.
   e. Arrestance (ASHRAE 52.1): 95.
   f. Merv (ASHRAE 52.2): 13.
   g. Media: Fibrous material with antimicrobial agent, **as directed**, constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.
   h. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
   i. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
5. Automatic Roll Filters:
   a. Factory-fabricated, automatic, motor-driven, roll type.
   b. Arrangement: Horizontal **OR** Vertical, **as directed**.
   c. Dust-Holding Capacity: as directed by the Owner.
   d. Initial Resistance: as directed by the Owner.
   e. Recommended Final Resistance: as directed by the Owner.
   f. Arrestance (ASHRAE 52.1): 80.
   g. Merv (ASHRAE 52.2): 5.
   h. Media: Compressed and rolled, fibrous-glass material viscous coated, and with antimicrobial agent, **as directed**.
   i. Holding Frame: Galvanized steel, with enclosed, clean media roll arranged to allow upstream replacement of filter media.
   j. Auxiliary Frame: Locate on downstream side of unit with downstream **OR** side, **as directed**, access.
   k. Final Filter: Extended-surface, retained-media **OR** nonsupported-media **OR** HEPA, **as directed**, filters.
   l. Control and Drive:
      1) Mechanism: Electric, gear-reducer, motor-driven, feed control equipped with manual media advance and runout switches for stopping media movement of filter bank and operating remote warning signal lights.

2) Manual Control: Manual switch to advance media and wired to override automatic controls.
3) Automatic Control: Prewired control package to advance media when filter resistance exceeds adjustable high limit **OR** after adjustable operating time, **as directed**.

6. Activated-Carbon Panel Filters:
   a. Factory-fabricated unit with activated-carbon media.
   b. Flat-Panel Media: Multilayer filter with inlet layer of polyester fibers, layer of activated-carbon granules bonded to fibers, layer of polyurethane foam, and housed in cardboard frame.
   c. Pleated Media: Multilayer filter with inlet layer of cotton and synthetic fibers and layer of activated-carbon granules bonded to synthetic fibers, formed into deep-V-shaped pleats and held by self-wire grid, and housed in nonflammable cardboard frame.
   d. Mounting Frames: Welded galvanized steel, with polyurethane gaskets and fasteners, capable of holding media and media frame in place and suitable for bolting together into built-up filter banks.
7. Activated-Carbon Filters:
   a. Factory-fabricated unit in deep-V arrangement with disposable panel prefilter.
   b. Media: Activated carbon mounted in removable carbon-cell trays of epoxy-coated steel.
   c. Activated-Carbon Capacity: 12 lb (5.4 kg) of activated carbon per 500 cfm (236 L/s) **OR** 8.8 lb (4.0 kg) of activated carbon per 2000 cfm (944 L/s), **as directed**, of airflow.
   d. Housing: 0.064-inch- (1.6-mm-) thick, galvanized steel, for side servicing through gasketed access doors on both sides. Equip housings with metal slide channel tracks to hold activated-carbon trays.
8. HEPA Filters:
   a. Factory-fabricated unit.
   b. Dust-Holding Capacity: as directed by the Owner.
   c. Initial Resistance: as directed by the Owner.
   d. Recommended Final Resistance: as directed by the Owner.
   e. Arrestance (ASHRAE 52.1): 95 percent on 0.3-micrometer D.O.P. particles **OR** 99.97 percent on 0.3-micrometer D.O.P. particles **OR** 99.9995 percent on 0.1- and 0.2-micrometer D.O.P. particles **OR** 99.99995 percent on 0.1- and 0.2-micrometer D.O.P. particles, **as directed**.
   f. Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators **OR** vinyl-coated aluminum separators **OR** separators of ribbons of filter media, **as directed**.
   g. Frame Material: 3/4-inch- (19-mm-) thick, fire-retardant plywood **OR** 3/4-inch- (19-mm-) thick, fire-retardant particleboard **OR** 3/4-inch- (19-mm-) thick plywood **OR** 3/4-inch- (19-mm-) thick particleboard **OR** Galvanized steel **OR** Aluminized steel **OR** Cadmium-plated steel **OR** Stainless steel **OR** Aluminum, **as directed**.
   h. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife edge in fluid-filled channel, **as directed**.
   i. Face Gasket: Neoprene expanded rubber **OR** Ceramic fiber **OR** Silicone, **as directed**.
   j. Mounting Frames: Downstream corners of holding device shall have cushion pads to protect media. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.
9. Filter Gage:
   a. 3-1/2-inch- (90-mm-) **OR** 2-inch- (50-mm-), **as directed**, diameter, diaphragm-actuated dial in metal case.
   b. Vent valves.
   c. Black figures on white background.
   d. Front recalibration adjustment.
   e. 2 **OR** 3, **as directed**, percent of full-scale accuracy.

f. Range: 0- to 0.5-inch wg (0 to 125 Pa) **OR** 0- to 1.0-inch wg (0 to 250 Pa) **OR** 0- to 2.0-inch wg (0 to 500 Pa) **OR** 0- to 3.0-inch wg (0 to 750 Pa) **OR** 0- to 4.0-inch wg (0 to 1000 Pa), **as directed**.

g. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm) aluminum **OR** plastic, **as directed**, tubing, and 2- or 3-way vent valves.

E. Dampers

1. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.
2. Damper Operators: Comply with requirements in Division 15 Section "Hvac Instrumentation And Controls".

   OR

   Electronic Damper Operators:

   a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
   c. Operator Motors:
      1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Work Results For Hvac".
      2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
      3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
   d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
   e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
   f. Size dampers for running torque calculated as follows:
      1) Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
      2) Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
      3) Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
      4) Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
      5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
      6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
   g. Coupling: V-bolt and V-shaped, toothed cradle.
   h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
   i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
   j. Power Requirements (Two-Position Spring Return): 24 **OR** 120 **OR** 230, **as directed**,-V ac.
   k. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
   l. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
   m. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) **OR** 40 to 104 deg F (5 to 40 deg C), **as directed**.

n. Run Time: 12 seconds open, 5 seconds closed **OR** 30 seconds **OR** 60 seconds **OR** 120 seconds, **as directed**.

OR

Pneumatic Damper Operators:

a. Rolling-diaphragm piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.

b. Pneumatic Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

c. Pilot Positioners:

1) Start Point: Adjustable from 2 to 12 psig (14 to 83 kPa).
2) Operating Span: Adjustable from 5 to 13 psig (35 to 90 kPa).
3) Linearity: Plus or minus 10 percent of output signal span.
4) Hysteresis: 3 percent of span.
5) Response: 0.25-psig (1723-Pa) input change.
6) Maximum Pilot Signal Pressure: 20 psig (140 kPa).
7) Maximum Control Air-Supply Pressure: 60 psig (410 kPa).

d. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F (10 to 60 deg C) unless located in return-air plenums, **as directed**.

e. Inlet-Vane Operators: High pressure, with pilot positioners.

3. Zone Dampers: Two single-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers offset 90 degrees from each other on cadmium-plated, **as directed,** steel operating rod rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

4. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with cadmium-plated, **as directed**, steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.

5. Outdoor- and Return-Air Mixing Dampers: Parallel-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers mechanically fastened to cadmium-plated, **as directed**, steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

6. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade **OR** parallel-blade, **as directed**, arrangement with cadmium-plated, **as directed**, steel operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).

7. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.

8. Combination Filter and Mixing Section:

a. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.

b. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

F. Humidifiers

1. Steam Grid Humidifier:

a. Manifold:

1) ASTM A 666, Type 304 stainless steel.
2) Steam jacketed.
3) Insulated with 1/2-inch (13-mm) fiberglass and stainless-steel jacket.
4) Manifold shall extend the full width of unit with mounting brackets at ends.

b. Steam Separator: Cast iron, **OR** ASTM A 666, Type 304 stainless steel, **as directed**, with separate, **as directed**, humidifier control valve.

c. Humidifier Control Valve: Actuator: Pneumatic **OR** Electric, **as directed**, modulating with spring return.
OR
Humidifier Control Valve: Actuator: As specified in Division 15 Section "Hvac Instrumentation And Controls".

d. Steam Trap: Inverted-bucket type, sized for a minimum of three times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) inlet pressure.

e. Aquastat: For separate mounting on steam condensate, return piping to prevent cold operation of humidifier.

f. Strainer: In-line type.

g. Airflow Switch: To prevent humidifier operation in the absence of airflow.

2. Wet Glass Cell Washer Section:

a. 3-inch- (75-mm-) deep cells with random packed, glass-fiber media in galvanized-steel **OR** stainless-steel, **as directed**, frames.

b. Access Door: Watertight with brass fittings, wire glass window, **as directed**, and locking handles.

c. Spray Tree Assembly: Brass **OR** Stainless-steel, **as directed**, nozzles and galvanized-steel **OR** stainless-steel, **as directed**, piping.

d. Eliminator: Galvanized-steel **OR** Stainless-steel, **as directed**, plates.

e. Tank:

1) Welded steel **OR** stainless steel, **as directed**, with interior and exterior surfaces blasted and painted with zinc-chromate paint, **as directed**.
2) Copper suction screen.
3) Drain, overflow, and suction connections.
4) Makeup connection with brass, **as directed**, float valve, and with quick-fill connection.

f. Insulate exterior with duct insulation and mount on 2-inch (-(50-mm-)) thick, rigid insulation board.

3. Evaporative Humidifier Section:

a. Access Door: Watertight cast iron, **as directed**, with brass fittings, wire glass window, and locking handles.

b. Spray Tree Assembly: Brass nozzles and galvanized piping, galvanized eliminator plates with flooding nozzles and header, and galvanized antisplash baffles **OR** cross-fluted cellulose media, **as directed**.

c. Tank:

1) Welded steel tank with interior and exterior surfaces blasted and painted with zinc-chromate paint.
2) Copper suction screen, drain, overflow, and suction connections.
3) Makeup connection with brass, **as directed**, float valve, and with quick-fill connection.

d. Insulation: Insulate with duct insulation on exterior and mount on 2-inch (-50-mm-) thick, rigid insulation board.

G. Air-To-Air Energy Recovery

1. Heat Wheels:

a. Casing:

1) Steel, with manufacturer's standard paint coating.
2) Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.

3) Casing seals on periphery of rotor, on duct divider, and on purge section.
4) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.

b. Rotor: Aluminum, segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating, **as directed**. Construct media for passing maximum 500 **OR** 800 **OR** 1200, **as directed**,-micrometer solids.
OR
Rotor: Glass-fiber **OR** Polymer, **as directed**, segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating. Construct media for passing maximum 800 **OR** 1200, **as directed**,-micrometer solids.

c. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, **as directed**, and self-adjusting multilink belt around outside of rotor.

d. Controls:
1) Starting relay, factory mounted and wired, and manual motor starter for field wiring.
2) Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.
OR
Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
OR
Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing, **as directed**, and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
3) Pilot-Light Indicator: Display rotor rotation and speed.
4) Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

2. Fixed-Plate Sensible Heat Exchangers:

a. Casing: Aluminum **OR** Galvanized steel **OR** Enameled steel, with galvanized-steel liner **OR** Enameled steel, **as directed**.

b. Plates: Evenly spaced and sealed and arranged for counter airflow.

c. Plate Material: Embossed aluminum **OR** Stainless steel **OR** Polypropylene copolymer (high-density plastic), **as directed**.
1) Plate Coating: Epoxy **OR** Air-dried phenolic, **as directed**.

d. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.

e. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection, **as directed**.

f. Heat-Exchanger Prefilters: 1 inch (25 mm) thick, disposable **OR** 2 inches (50 mm) thick, disposable **OR** Medium efficiency **OR** Electrostatic, **as directed**.

H. Source Quality Control

1. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
2. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
3. Water Coils: Factory tested to 300 psig (2070 kPa) according to ARI 410 and ASHRAE 33.
4. Steam Coils: Factory tested to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater according to ARI 410 and ASHRAE 33.
5. Refrigerant Coils: Factory tested to 450 psig (3105 kPa) according to ARI 410 and ASHRAE 33.

1.3 EXECUTION

A. Installation

1. Equipment Mounting: Install air-handling units on concrete bases using elastomeric pads **OR** using elastomeric mounts **OR** using restrained spring isolators **OR** without vibration isolation devices, **as directed**. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   a. Minimum Deflection: 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
   b. Install galvanized-steel **OR** stainless-steel, **as directed**, plate to equally distribute weight over elastomeric pad.
   c. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   d. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   e. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   f. Install anchor bolts to elevations required for proper attachment to supported equipment.

   OR

   Equipment Mounting: Install air-handling unit using elastomeric pads **OR** using elastomeric mounts **OR** using restrained spring isolators **OR** without vibration isolation devices, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
   g. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm) **OR** 1 inch (25 mm) **OR** 2 inches (50 mm) **OR** 3 inches (75 mm), **as directed**.
   h. Install galvanized-steel **OR** stainless-steel, **as directed**, plate to equally distribute weight over elastomeric pad.
2. Suspended Units: Suspend and brace, **as directed**, units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Arrange installation of units to provide access space around air-handling units for service and maintenance.
4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
5. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

B. Connections

1. Comply with requirements for piping specified in other Division 15. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to air-handling unit to allow service and maintenance.
3. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
4. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B 88, Type M (ASTM B 88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
5. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 15 Section "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
6. Steam and Condensate Piping: Comply with applicable requirements in Division 15 Section "Steam And Condensate Piping". Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet

strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

7. Refrigerant Piping: Comply with applicable requirements in Division 15 Section "Refrigerant Piping". Install shutoff valve and union or flange at each supply and return connection.
8. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 15 Section "Duct Accessories".

C. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   b. Charge refrigerant coils with refrigerant and test for leaks.
   c. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   d. Automatic-Roll-Filter Operational Test: Operate filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating.
   e. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
   f. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510, pressure-decay method.
   g. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
4. Prepare test and inspection reports.

D. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Verify that shipping, blocking, and bracing are removed.
   c. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
   d. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
   e. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
   f. Verify that zone dampers fully open and close for each zone.
   g. Verify that face-and-bypass dampers provide full face flow.
   h. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
   i. Comb coil fins for parallel orientation.
   j. Verify that proper thermal-overload protection is installed for electric coils.
   k. Install new, clean filters.
   l. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
2. Starting procedures for air-handling units include the following:
   a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions, **as directed**.
   b. Measure and record motor electrical values for voltage and amperage.

c. Manually operate dampers from fully closed to fully open position and record fan performance.

E. Adjusting
1. Adjust damper linkages for proper damper operation.
2. Comply with requirements in Division 15 Section "Testing, Adjusting, And Balancing" for air-handling system testing, adjusting, and balancing.

F. Cleaning
1. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 15834

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Task	Specification	Specification Description
15834	07670	Roof Accessories

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SECTION 15840 - TAILPIPE EXHAUST EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of tailpipe exhaust equipment. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals
1. Product Data: For each type of product indicated.

1.2 PRODUCTS

A. Capacity and Performance
1. Based on standard air density (0.075 pound per cubic foot). Fans shall have a peak static efficiency of not less than 60 percent.

B. Blowers and Accessories
1. Comply with AMCA 210, 300, and 301. Fan impellers shall be constructed of heavy gauge steel and accurately balanced both statically and dynamically when installed in the assembled fan unit. Impeller and housing in the air stream shall be coated with neoprene, epoxy, phenolic resins, or other material suitable to resist the corrosive gases and temperatures encountered. Fans to be mounted on exterior of building shall be provided with weatherproof covers.

C. Exhaust Duct and Fittings for Vehicle Tailpipe Exhaust Systems
1. Constructed of galvanized sheet steel, conforming to ASTM A 525. Ductwork shall be constructed with minimum metal gauge thickness and reinforced as required in the SMACNA Duct Construction Standards - Metal and Flexible.
a. Tailpipe Adapter shall be not less than 20-gauge corrosion-resisting steel. The adapter shall be of the tapered cone type with spring clip or other suitable device for exhaust pipe attachment.
b. Flexible Exhaust Tubing shall be 0.012 minimum thickness galvanized sheet steel or heat-resistant, reinforced wire, fiberglass, and neoprene tubing.
c. Dampers shall be of the circular disk type with quadrant locking device or blast gate type.
d. A Flexible Tubing Suspension System shall be furnished and installed for repaired tailpipe exhaust systems where no such suspension system exists. The flexible tubing suspension system shall suspend the flexible tubing overhead when not in use, allowing it to be lowered to the operating level, when required. The suspension system installed shall be complete with cable, pulleys, and operating mechanism.

1.3 EXECUTION

A. Ductwork joints in galvanized sheet steel ductwork shall be soldered or otherwise sealed. The lock seam in straight sections shall be located on top of the duct. Seams shall be suitable for 10-inch water gauge static pressure. Ductwork shall be constructed with minimum metal gauge thickness and reinforced as required in the SMACNA Duct Construction Standards - Metal and Flexible.

B. Weather-Resistant Finishes of items located outdoors shall meet the requirements of ASTM B 117.

END OF SECTION 15840

SECTION 15840a - METAL DUCTS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for metal ducts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
   a. Single-wall rectangular ducts and fittings.
   b. Double-wall rectangular ducts and fittings.
   c. Single-wall round and flat-oval ducts and fittings.
   d. Double-wall round and flat-oval ducts and fittings.
   e. Sheet metal materials.
   f. Duct liner.
   g. Sealants and gaskets.
   h. Hangers and supports.
   i. Seismic-restraint devices.

C. Performance Requirements

1. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
2. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
   a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
      OR
      Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
      OR
      Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Submittals

1. Product Data: For each type of the following products:
   a. Liners and adhesives.
   b. Sealants and gaskets.
   c. Seismic-restraint devices.
2. LEED Submittals:
   a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
   b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."
   c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2004, Section 6.4.4.2.2 - "Duct Leakage Tests."
   d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1-2004, Section 7.2.4 - "Ventilation System Start-Up."

e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

3. Shop Drawings:
   a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   b. Factory- and shop-fabricated ducts and fittings.
   c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
   d. Elevation of top of ducts.
   e. Dimensions of main duct runs from building grid lines.
   f. Fittings.
   g. Reinforcement and spacing.
   h. Seam and joint construction.
   i. Penetrations through fire-rated and other partitions.
   j. Equipment installation based on equipment being used on Project.
   k. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
   l. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
4. Delegated-Design Submittal:
   a. Sheet metal thicknesses.
   b. Joint and seam construction and sealing.
   c. Reinforcement details and spacing.
   d. Materials, fabrication, assembly, and spacing of hangers and supports.
   e. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.
5. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
   b. Suspended ceiling components.
   c. Structural members to which duct will be attached.
   d. Size and location of initial access modules for acoustical tile.
   e. Penetrations of smoke barriers and fire-rated construction.
   f. Items penetrating finished ceiling including the following:
      1) Lighting fixtures.
      2) Air outlets and inlets.
      3) Speakers.
      4) Sprinklers.
      5) Access panels.
      6) Perimeter moldings.
6. Welding certificates.
7. Field quality-control reports.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to the following:
   a. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
   b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
   c. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

1.2 PRODUCTS

A. Single-Wall Rectangular Ducts And Fittings
1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
2. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Double-Wall Rectangular Ducts And Fittings
1. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
2. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
5. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
   b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   c. Coat insulation with antimicrobial coating.
   d. Cover insulation with polyester film complying with UL 181, Class 1.

   OR
6. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
   a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
7. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent **OR** solid sheet steel, **as directed**.
8. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Traverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

9. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Single-Wall Round And Flat-Oval Ducts And Fittings
1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
2. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   a. Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
   b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
5. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Double-Wall Round And Flat-Oval Ducts And Fittings
1. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
2. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
   a. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
      1) Transverse Joints in Ducts Larger Than 60 Inches (1524 mm) in Diameter: Flanged.
   b. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
      1) Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
      2) Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
   c. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements,

materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent **OR** solid sheet steel, **as directed**.
4. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
   b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
   c. Coat insulation with antimicrobial coating.
   d. Cover insulation with polyester film complying with UL 181, Class 1.

   OR
5. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
   a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.

E. Sheet Metal Materials
1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   a. Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
   b. Finishes for Surfaces Exposed to View: Mill phosphatized.
3. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   a. Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
   b. Minimum Thickness for Factory-Applied PVC Coating: 4 mils (0.10 mm) thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil (0.025 mm) thick on opposite surface, **as directed**.
   c. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
4. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
5. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
6. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
7. Factory- or Shop-Applied Antimicrobial Coating:
   a. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
   b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   c. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
   d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   e. Shop-Applied Coating Color: Black **OR** White, **as directed**.
   f. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
8. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

a. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

9. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

F. Duct Liner

1. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   a. Maximum Thermal Conductivity:
      1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
      2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
   b. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   c. Solvent-Based **OR** Water-Based, **as directed**, Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
      1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
   a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
   b. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
      1) For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.
   a. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature when tested according to ASTM C 518.
   b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
   c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
      1) For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Insulation Pins and Washers:
   a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   b. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel **OR** aluminum **OR** stainless steel, **as directed**; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
5. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
   a. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
   b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

c. Butt transverse joints without gaps, and coat joint with adhesive.
d. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
e. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
f. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm (12.7 m/s).
g. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
h. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
   1) Fan discharges.
   2) Intervals of lined duct preceding unlined duct.
   3) Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
i. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   1) Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
j. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

G. Sealant And Gaskets
1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
2. Two-Part Tape Sealing System:
   a. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   b. Tape Width: 3 inches (76 mm) **OR** 4 inches (102 mm) **OR** 6 inches (152 mm), **as directed**.
   c. Sealant: Modified styrene acrylic.
   d. Water resistant.
   e. Mold and mildew resistant.
   f. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   g. Service: Indoor and outdoor.
   h. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
   i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   j. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Water-Based Joint and Seam Sealant:
   a. Application Method: Brush on.
   b. Solids Content: Minimum 65 percent.
   c. Shore A Hardness: Minimum 20.
   d. Water resistant.
   e. Mold and mildew resistant.
   f. VOC: Maximum 75 g/L (less water).
   g. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   h. Service: Indoor or outdoor.

i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

4. Solvent-Based Joint and Seam Sealant:
   a. Application Method: Brush on.
   b. Base: Synthetic rubber resin.
   c. Solvent: Toluene and heptane.
   d. Solids Content: Minimum 60 percent.
   e. Shore A Hardness: Minimum 60.
   f. Water resistant.
   g. Mold and mildew resistant.
   h. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   i. VOC: Maximum 395 g/L.
   j. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
   k. Service: Indoor or outdoor.
   l. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
5. Flanged Joint Sealant: Comply with ASTM C 920.
   a. General: Single-component, acid-curing, silicone, elastomeric.
   b. Type: S.
   c. Grade: NS.
   d. Class: 25.
   e. Use: O.
   f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
7. Round Duct Joint O-Ring Seals:
   a. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
   b. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   c. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

H. Hangers And Supports
1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
4. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
5. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
6. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
7. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
8. Trapeze and Riser Supports:
   a. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   b. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
   c. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

I. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR**

the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.

a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
3. Restraint Cables: ASTM A 603, galvanized-steel **OR** ASTM A 492, stainless-steel, **as directed**, cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.3 EXECUTION

A. Duct Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
2. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
3. Install round and flat-oval ducts in maximum practical lengths.
4. Install ducts with fewest possible joints.
5. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
6. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
7. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
8. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
9. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
10. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
11. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 15 Section "Duct Accessories" for fire and smoke dampers.
12. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines", **as directed**.

B. Installation Of Exposed Ductwork

1. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
2. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
3. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

4. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
5. Repair or replace damaged sections and finished work that does not comply with these requirements.

C. Additional Installation Requirements For Commercial Kitchen Hood Exhaust Duct
1. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
2. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet (6 m) **OR** 12 feet (3.7 m), **as directed**, in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches (38 mm) from bottom of duct.
3. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

D. Duct Sealing
1. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
OR
Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
a. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
b. Outdoor, Supply-Air Ducts: Seal Class A.
c. Outdoor, Exhaust Ducts: Seal Class C.
d. Outdoor, Return-Air Ducts: Seal Class C.
e. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
f. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
g. Unconditioned Space, Exhaust Ducts: Seal Class C.
h. Unconditioned Space, Return-Air Ducts: Seal Class B.
i. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
j. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
k. Conditioned Space, Exhaust Ducts: Seal Class B.
l. Conditioned Space, Return-Air Ducts: Seal Class C.

E. Hanger And Support Installation
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
a. Where practical, install concrete inserts before placing concrete.
b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
e. Do not use powder-actuated concrete fasteners for seismic restraints.
3. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and

supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

4. Hangers Exposed to View: Threaded rod and angle or channel supports.
5. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

F. Seismic-Restraint-Device Installation
1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
   a. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
   b. Brace a change of direction longer than 12 feet (3.7 m).
2. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install cable restraints on ducts that are suspended with vibration isolators.
5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
7. Drilling for and Setting Anchors:
   a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   d. Set anchors to manufacturer's recommended torque, using a torque wrench.
   e. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

G. Connections
1. Make connections to equipment with flexible connectors complying with Division 15 Section "Duct Accessories".
2. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

H. Painting
1. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 07.

I. Field Quality Control
1. Perform tests and inspections.
2. Leakage Tests:
   a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.

b. Test the following systems:
   1) Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 25 percent of total installed duct area for each designated pressure class.
   2) Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
   3) Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
   4) Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
   5) Outdoor Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
d. Test for leaks before applying external insulation.
e. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
f. Give seven days' advance notice for testing.

3. Duct System Cleanliness Tests:
   a. Visually inspect duct system to ensure that no visible contaminants are present.
   b. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
4. Duct system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

J. Duct Cleaning
1. Clean new **OR** existing **OR** new and existing, **as directed**, duct system(s) before testing, adjusting, and balancing.
2. Use service openings for entry and inspection.
   a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 15 Section "Duct Accessories" for access panels and doors.
   b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   c. Remove and reinstall ceiling to gain access during the cleaning process.
3. Particulate Collection and Odor Control:
   a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

4. Clean the following components by removing surface contaminants and deposits:
   a. Air outlets and inlets (registers, grilles, and diffusers).
   b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   d. Coils and related components.
   e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
   f. Supply-air ducts, dampers, actuators, and turning vanes.
   g. Dedicated exhaust and ventilation components and makeup air systems.
5. Mechanical Cleaning Methodology:
   a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
   d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
   e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
   f. Provide drainage and cleanup for wash-down procedures.
   g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

K. Start Up
1. Air Balance: Comply with requirements in Division 15 Section "Testing, Adjusting, And Balancing".

L. Duct Schedule
1. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
   a. Underground Ducts: Concrete-encased, galvanized sheet steel **OR** PVC-coated, galvanized sheet steel with thicker coating on duct exterior **OR** stainless steel, **as directed**.
2. Supply Ducts:
   a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
      1) Pressure Class: Positive 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa), **as directed**.
      2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**.
      3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
      4) SMACNA Leakage Class for Round and Flat Oval: 12 **OR** 24, **as directed**.
   b. Ducts Connected to Constant-Volume Air-Handling Units:
      1) Pressure Class: Positive 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
      2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
      3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
      4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.
   c. Ducts Connected to Variable-Air-Volume Air-Handling Units:
      1) Pressure Class: Positive 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.

2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
3) SMACNA Leakage Class for Rectangular: 3 **OR** 6, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6, **as directed**.

d. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Positive 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed**.

3. Return Ducts:

a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
1) Pressure Class: Positive or negative 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**.
3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 12 **OR** 24, **as directed**.

b. Ducts Connected to Air-Handling Units:
1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.

c. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed**.

4. Exhaust Ducts:

a. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
1) Pressure Class: Negative 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**, if negative pressure, and A if positive pressure.
3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.

b. Ducts Connected to Air-Handling Units:
1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**, if negative pressure, and A if positive pressure.
3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed**.

c. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
1) Exposed to View: Type 304, stainless-steel sheet, No. 4 **OR** No. 3, **as directed**, finish.
2) Concealed: Type 304, stainless-steel sheet, No. 2D finish **OR** Carbon-steel sheet, **as directed**.
3) Welded seams and joints.
4) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
5) Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
6) SMACNA Leakage Class: 3.

d. Ducts Connected to Dishwasher Hoods:

1) Type 304, stainless-steel sheet.
2) Exposed to View: No. 4 **OR** No. 3, **as directed**, finish.
3) Concealed: No. 2D finish.
4) Welded seams and flanged joints with watertight EPDM gaskets.
5) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
6) Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
7) SMACNA Leakage Class: 3.

e. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
1) Type 316 **OR** Type 304, **as directed**, stainless-steel sheet.
a) Exposed to View: No. 4 **OR** No. 3, **as directed**, finish.
b) Concealed: No. 2B **OR** No. 2D, **asdrected**, finish.
OR
PVC-coated, galvanized sheet steel with thicker coating on duct interior.
2) Pressure Class: Positive or negative 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa) **OR** 6-inch wg (1500 Pa), **as directed**.
3) Minimum SMACNA Seal Class: A **OR** Welded seams, joints, and penetrations, **as directed**.
4) SMACNA Leakage Class: 3.

f. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **a directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**, if negative pressure, and A if positive pressure.
3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed**.

5. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
1) Pressure Class: Positive or negative 1-inch wg (250 Pa) **OR** 2-inch wg (500 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed**.
3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed**.

b. Ducts Connected to Air-Handling Units:
1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed**.

c. Ducts Connected to Equipment Not Listed Above:
1) Pressure Class: Positive or negative 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**.
2) Minimum SMACNA Seal Class: A **OR** B, **as directed**.
3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed**.
4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed**.

6. Intermediate Reinforcement:
a. Galvanized-Steel Ducts: Galvanized steel **OR** Carbon steel coated with zinc-chromate primer **OR** Galvanized steel or carbon steel coated with zinc-chromate primer, **as directed**.
b. PVC-Coated Ducts:
1) Exposed to Airstream: Match duct material.
2) Not Exposed to Airstream: Galvanized **OR** Match duct material, **as directed**.
c. Stainless-Steel Ducts:
1) Exposed to Airstream: Match duct material.

2) Not Exposed to Airstream: Galvanized **OR** Match duct material, **as directed**.

d. Aluminum Ducts: Aluminum **OR** galvanized sheet steel coated with zinc chromate, **as directed**.

7. Liner:

a. Supply Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.

b. Return Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.

c. Exhaust Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) thick.

d. Supply Fan Plenums: Fibrous glass, Type II **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.

e. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 2 inches (51 mm) thick.

f. Transfer Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.

8. Double-Wall Duct Interstitial Insulation:

a. Supply Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.

b. Return Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm, **as directed**, thick.

c. Exhaust Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as direcrted**, thick.

9. Elbow Configuration:

a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

1) Velocity 1000 fpm (5 m/s) or Lower:

a) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.

b) Mitered Type RE 4 without vanes.

2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

a) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.

b) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.

c) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

3) Velocity 1500 fpm (7.6 m/s) or Higher:

a) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

b) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

c) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

OR

b. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."

1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.

2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

c. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."

1) Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
   a) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
   b) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
   c) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
   d) Radius-to Diameter Ratio: 1.5.
2) Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
3) Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam **OR** Welded, **as directed**.

10. Branch Configuration:
    a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
       1) Rectangular Main to Rectangular Branch: 45-degree entry.
       2) Rectangular Main to Round Branch: Spin in.
    b. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
       1) Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
       2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
       3) Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 15840a

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SECTION 15840b - NONMETAL DUCTS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for nonmetal ducts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fibrous-glass ducts and fittings.
b. Phenolic-foam ducts and fittings.
c. Thermoset FRP ducts and fittings.
d. PVC ducts and fittings.

C. Performance Requirements
1. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with SMACNA's "Fibrous Glass Duct Construction Standards" and performance requirements and design criteria indicated.
a. Static-Pressure Classes:
1) Supply Ducts (except in Mechanical Rooms): 1-inch wg (250 Pa).
2) Supply Ducts (Upstream from Air Terminal Units): 2-inch wg (500 Pa).
3) Supply Ducts (Downstream from Air Terminal Units): 1-inch wg (250 Pa).
4) Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa).
5) Return Ducts (Negative Pressure): 1-inch wg (250 Pa).
6) Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).
2. Structural Performance: Duct hangers and supports and seismic restraints, **as directed**, shall withstand the effects of gravity and seismic, **as directed**, loads and stresses within limits and under conditions to comply with ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
OR
Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
OR
Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."
c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2004, Section 6.4.4.2.2 - "Duct Leakage Tests."
d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1-2004, Section 7.2.4 - "Ventilation System Start-Up."
e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

3. Shop Drawings:
   a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   b. Duct layout indicating sizes and pressure classes.
   c. Elevation of top of ducts.
   d. Dimensions of main duct runs from building grid lines.
   e. Fittings.
   f. Reinforcement and spacing.
   g. Seam and joint construction.
   h. Penetrations through fire-rated and other partitions.
   i. Equipment installation based on equipment being used on Project.
   j. Hangers and supports, including methods for duct and building attachment, seismic restraints, **as directed**, and vibration isolation.
4. Delegated-Design Submittal:
   a. Duct materials and thicknesses.
   b. Joint and seam construction and sealing.
   c. Reinforcement details and spacing.
   d. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**, for selecting hangers and supports and seismic restraints, **as directed**.
5. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
   b. Suspended ceiling components.
   c. Structural members to which duct will be attached.
   d. Size and location of initial access modules for acoustical tile.
   e. Penetrations of smoke barriers and fire-rated construction.
   f. Items penetrating finished ceiling including the following:
      1) Lighting fixtures.
      2) Air outlets and inlets.
      3) Speakers.
      4) Sprinklers.
      5) Access panels.
      6) Perimeter moldings.
6. Welding certificates.
7. Field quality-control reports.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports **OR** AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports, **as directed**.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."
4. NFPA Compliance:
   a. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
   b. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.2 PRODUCTS

A. Fibrous-Glass Ducts And Fittings

1. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.
   a. Duct Board: Factory molded into rectangular boards.
   b. Round Duct: Factory molded into straight round duct and smooth fittings.
   c. Temperature Limits: 40 to 250 deg F (5 to 121 deg C) inside ducts; 150 deg F (66 deg C) ambient temperature surrounding ducts.
   d. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.035 W/m x K) at 75 deg F (24 deg C) mean temperature.
   e. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F (49 deg C) and 95 percent relative humidity for 96 hours when tested according to ASTM C 1104/C 1104M.
   f. Permeability: 0.02 perms (1.15 ng/Pa x s x sq. m) maximum when tested according to ASTM E 96/E 96M, Procedure A.
   g. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
   h. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.
   i. Required Markings: EI rating, UL label, and other markings required by UL 181 on each full sheet of duct board.
2. Closure Materials:
   a. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-P," the manufacturer's name, and a date code.
      1) Tape: Aluminum foil-scrim tape imprinted with listing information.
      2) Minimum Tape Width: 2-1/2 inches (64 mm); 3 inches (76 mm) for duct board thicker than 1 inch (25 mm).
      3) Staples: 1/2-inch (13-mm) outward clinching, 2 inches (51 mm) o.c. in tabs, one tab per joint.
      4) Water resistant.
      5) Mold and mildew resistant.
   b. Heat-Activated Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-H," the manufacturer's name, and a date code.
      1) Tape: Aluminum foil-scrim tape imprinted with listing information.
      2) Minimum Tape Width: 3 inches (76 mm).
      3) Heat-Sensitive Imprint: Printed indicator on tape to show proper heating during application has been achieved.
      4) Water resistant.
      5) Mold and mildew resistant.
   c. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-M," the manufacturer's name, and a date code.
      1) Tape: Woven glass fiber impregnated with mineral gypsum.
      2) Minimum Tape Width: 3 inches (76 mm).
      3) Sealant: Modified styrene acrylic.
      4) Water resistant.
      5) Mold and mildew resistant.
      6) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
   a. Select joints, seams, transitions, elbows, and branch connections and fabricate according to SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 2, "Specifications and Closure," and Chapter 4, "Fittings and Connections" **OR** NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section II, "Fabrication of Straight Duct Modules," Section III, "Fabrication of Fittings from Modules or Flat Board," and Section IV, "Closure", **as directed**.
   b. Fabricate 90-degree mitered elbows to include turning vanes.
   c. Reinforcements: Comply with requirements in SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 5, "Reinforcement" **OR** NAIMA AH116, "Fibrous Glass

Duct Construction Standards," Section V, "Reinforcement", **as directed**, for channel- and tie-rod reinforcement materials, spacing, and fabrication.

d. Preformed Round Duct: Comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VII, "Preformed Round Duct."

B. Phenolic-Foam Ducts And Fittings

1. Duct Panel: CFC-free phenolic-foam bonded on both sides with factory-applied 0.001-inch-(0.025-mm-) thick, aluminum foil reinforced with fiberglass scrim.
   a. Maximum Temperature: 158 deg F (70 deg C) inside ducts or ambient temperature surrounding ducts.
   b. Maximum Thermal Conductivity: 0.13 Btu x in./h x sq. ft. x deg F (0.019 W/m x K) at 75 deg F (24 deg C) mean temperature.
   c. Permeability: 0.0002 perms (0.0115 ng/Pa x s x sq. m) maximum when tested according to ASTM E 96/E 96M, Procedure A.
   d. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
   e. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.
   f. Required Markings: UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for closure materials.
2. Closure Materials:
   a. V-Groove Adhesive: Silicone.
      1) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-P," the manufacturer's name, and a date code.
      1) Tape: Aluminum foil tape imprinted with listing information.
      2) Minimum Tape Width: 3 inches (76 mm).
      3) Water resistant.
      4) Mold and mildew resistant.
   c. Polymeric Sealing System:
      1) Structural Membrane: Woven glass fiber.
      2) Minimum Tape Width: 3 inches (76 mm).
      3) Sealant: Water based.
      4) Color: White.
      5) Water resistant.
      6) Mold and mildew resistant.
      7) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
   a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to Knauf Insulation's "Knauf KoolDuct System Design Guide," Section 4, "Duct Construction," and Section 5, "Ductwork System General."
   b. Fabricate 90-degree mitered elbows to include turning vanes.

C. Thermoset FRP Ducts And Fittings

1. Duct and Fittings:
   a. Thermoset FRP Resin: Manufacture duct with resin that complies with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E 84.
   b. Inner Liner: FSK liner rated by an NRTL to comply with UL 181, Class 1.
   c. Round Duct: ASTM D 2996, Type I, Grade 2, Class E, filament-wound duct, minimum 0.125-inch (3.2-mm) wall thickness, with tapered bell and spigot ends for adhesive joints, or plain ends with couplings.

d. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.
e. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with fiberglass roving and resin-reinforced joints and seams.
f. Double-Wall Insulated Duct: Inner and outer duct complying with requirements for "Round Duct" description above. Polyurethane foam or isocyanurate insulation with maximum thermal conductivity of 0.14 Btu x in./h x sq. ft. x deg F (0.020 W/m x K) at 75 deg F (24 deg C) mean temperature.

2. Joining Materials: Roving and polyester resin.
   a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
   a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
   b. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
4. Drains: Formed drain pockets with a minimum of NPS 1 (DN 25) threaded pipe connections.

D. PVC Ducts And Fittings
1. Duct and Fittings:
   a. Round Duct: Comply with cell Classification 12454-B in ASTM D 1784, with external loading properties of ASTM D 2412.
   b. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
   c. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with heat-formed corners and continuous welded butt joints.
2. Joining Materials: PVC solvent cement complying with ASTM D 2564.
   a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
   a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems."
   b. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
4. Drains: PVC drain pockets with a minimum of NPS 1 (DN 25) threaded PVC pipe connections.

E. Hangers And Supports
1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
4. Steel Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, steel with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
5. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
6. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

F. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
   a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
3. Restraint Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**,-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.3 EXECUTION

A. Duct Installation
1. Install ducts with fewest possible joints.
2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
4. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
5. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
6. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 15 Section "Duct Accessories" for fire and smoke dampers.
7. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines", **as directed**.
8. Install fibrous-glass ducts and fittings to comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards **OR** SMACNA's "Fibrous Glass Duct Construction Standards", **as directed**.
9. Install foam ducts and fittings to comply with Knauf Insulation's "Knauf KoolDuct System Design Guide."
10. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."
11. Install PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."

B. Hanger And Support Installation
1. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 6, "Hangers and Supports" **OR** NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VI, "Hangers and Supports", **as directed**.
2. Install hangers and supports for phenolic-foam ducts and fittings to comply with Knauf Insulation's "Knauf KoolDuct System Design Guide," Section 5, "Ductwork System General."

3. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
4. Install hangers and supports for PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems."
5. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   a. Install concrete inserts before placing concrete.
   b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
   d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
   e. Do not use powder-actuated concrete fasteners for seismic restraints.
6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

C. Seismic-Restraint-Device Installation
1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
   a. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
   b. Brace a change of direction longer than 12 feet (3.7 m).
2. Select sizes of components so strength will be adequate to carry present and future static and seismic loads within restraint device capacity.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install cable restraints where ducts are suspended with vibration isolators.
5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directeed**.
6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.
7. Drilling for and Setting Anchors:
   a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   d. Set anchors to manufacturer's recommended torque, using a torque wrench.
   e. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

D. Painting
1. Paint interior of thermoset FRP and PVC ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 07.

E. Field Quality Control
1. Perform tests and inspections.
2. Leakage Tests:

a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
b. Test the following systems:
   1) Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 25 percent of total installed duct area for each designated pressure class.
   2) Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
   3) Return Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
   4) Exhaust Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
   5) Outdoor Air Ducts with a Pressure Class of 2-Inch wg (500 Pa) **OR** 3-Inch wg (750 Pa) **OR** 4-Inch wg (1000 Pa), **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
d. Test for leaks before applying external insulation.
e. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

3. Duct System Cleanliness Tests:
   a. Visually inspect duct system to ensure that no visible contaminants are present.
   b. Test sections of nonmetal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
4. Duct system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

F. Duct Cleaning
1. Clean new **OR** existing **OR** new and existing, **as directed**, duct system(s) before testing, adjusting, and balancing.
2. Use service openings for entry and inspection.
   a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Division 15 Section "Duct Accessories" for access panels and doors.
   b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
   c. Remove and reinstall ceiling to gain access during the cleaning process.
3. Particulate Collection and Odor Control:

a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

4. Clean the following components by removing surface contaminants and deposits:
   a. Air outlets and inlets (registers, grilles, and diffusers).
   b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
   d. Coils and related components.
   e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
   f. Supply-air ducts, dampers, actuators, and turning vanes.
   g. Dedicated exhaust and ventilation components and makeup air systems.
5. Mechanical Cleaning Methodology:
   a. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   b. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
   c. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
   d. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
   e. Provide drainage and cleanup for wash-down procedures.
   f. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

G. Start Up
1. Air Balance: Comply with requirements in Division 15 Section "Testing, Adjusting, And Balancing".

H. Duct Schedule
1. Indoor Ducts and Fittings:
   a. Fibrous-Glass Rectangular Ducts and Fittings:
      1) Minimum Flexural Rigidity: EI-475 **OR** 800 **OR** 1400, **as directed**.
      2) Minimum Board Thickness: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**.
   b. Fibrous-Glass Round Ducts and Fittings:
      1) Minimum Thickness: 1 inch (25 mm).
   c. Phenolic-Foam Rectangular Ducts and Fittings:
      1) Minimum Panel Thickness: 7/8 inch (22 mm) **OR** 1-3/32 inches (28 mm), **as directed**.
      2) Aluminum Cladding: Minimum 0.025 inch (0.635 mm) thick.
2. Outdoor Ducts and Fittings:
   a. Phenolic-Foam Rectangular Ducts and Fittings:
      1) Minimum Panel Thickness: 7/8 inch (22 mm) **OR** 1-3/32 inches (28 mm), **as directed**.
      2) Aluminum Cladding: Minimum 0.032 inch (0.813 mm) thick.

3) Polymeric Sealing System: Coat ducts, including gang-nail couplings, grip flanges, and couplings.

b. Thermoset FRP Round Ducts and Fittings:

1) Double-Wall Insulated Ducts: Minimum 5/8-inch (15.9-mm) **OR** 7/8-inch (22.2-mm), **as directed**, insulation thickness.

c. PVC Round Ducts and Fittings:

3. Underground Ducts:

a. Thermoset FRP Round Ducts and Fittings:

1) Insulation Thickness: 1 inch (25 mm).

2) Drain: Minimum NPS 1 (DN 25) PVC pipe with P-trap to air-gap drain.

b. PVC Round Ducts and Fittings:

1) Drain: Minimum NPS 1 (DN 25) PVC pipe with P-trap to air-gap drain.

END OF SECTION 15840b

SECTION 15840c - HVAC CASINGS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for HVAC casings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Factory- and Shop-fabricated, field-assembled, single- and double-wall casings for HVAC equipment.

C. Performance Requirements
1. Static-Pressure Classes:
a. Upstream from Fan(s): 2-inch wg (500 Pa).
b. Downstream from Fan(s): 2-inch wg (500 Pa) **OR** 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa) **OR** 6-inch wg (1500 Pa) **OR** 10-inch wg (2500 Pa), **as directed**.
2. Acoustical Performance:
a. NRC: 1.09 **OR** 0.94, **as directed**, according to ASTM C 423.
b. STC: 40 **OR** 34, **as directed**, according to ASTM E 90.
3. Structural Performance:
a. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed 1/8 inch per foot (0.97 mm per meter) of width.
1) Fabricate outdoor casings to withstand wind load of 15 lbf/sq. ft. (720 N/sq. m) and snow load of 30 lbf/sq. ft. (1440 N/sq. m).
4. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittals:
a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."
c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2004, Section 6.4.4.2.2 - "Duct Leakage Tests."
d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1-2004, Section 7.2.4 - "Ventilation System Start-Up."
e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For HVAC casings. Include plans, elevations, sections, components, and attachments to other work.
4. Welding certificates.
5. Field quality-control reports.

E. Quality Assurance
1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports **OR** AWS D9.1M/D9.1, "Sheet Metal Welding Code," for casing joint and seam welding, **as directed**.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

1.2 PRODUCTS

A. General Casing Fabrication Requirements
1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 6, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
   a. Fabricate casings with more than 3-inch wg (750-Pa) negative static pressure according to SMACNA's "Rectangular Industrial Duct Construction Standards."
   b. Casings with more than 2-inch wg (500-Pa) positive static pressure may be fabricated according to SMACNA's "Rectangular Industrial Duct Construction Standards."
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   a. Exterior Surface Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275), **as directed**.
   b. Interior Surface Galvanized Coating Designation:
      1) Sections Not Exposed to Moisture: G60 (Z180) **OR** G90 (Z275), **as directed**.
      2) Sections Housing and Downstream from Cooling Coil and Humidifiers: G90 (Z275).
3. Stainless Steel: ASTM A 480/A 480M, Type 304 **OR** Type 316, **as directed**, and having a No. 2D, **as directed**, finish.
4. Factory- or Shop-Applied Antimicrobial Coating:
   a. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
   b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   c. Coating containing the antimicrobial compound shall have a hardness of 2H minimum when tested according to ASTM D 3363.
   d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to UL 723; certified by an NRTL.
   e. Applied Coating Color: Standard **OR** Black **OR** White, **as directed**.
5. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
6. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.
7. Penetrations: Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.
8. Access Doors: Fabricate access doors according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-11, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 6.12, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and according to pressure class of the plenum or casing section in which access doors are to be installed.
   a. Size: 20 by 54 inches (500 by 1370 mm).
   b. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
   c. Hinges: Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

d. Latches: Minimum of two wedge-lever-type latches, operable from inside and outside.
e. Neoprene gaskets around entire perimeters of door frames.
f. Doors shall open against air pressure.

9. Condensate Drain Pans: Formed sections of Type 304, stainless-steel sheet **OR** G90 (Z275) coated, galvanized sheet steel, **as directed**, complying with requirements in ASHRAE 62.1. Pans shall extend a minimum of 12 inches (300 mm) past coil.
   a. Double-wall construction shall have space between walls filled with foam insulation and sealed moisture tight.
   b. Intermediate drain pan or drain trough shall collect condensate from top coil for units with stacked coils or stacked eliminators.
   c. Insulation: Polystyrene or polyurethane.
   d. Slopes shall be in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
   e. Each drain pan connection shall have a trap. Drain traps with depth and height differential between inlet and outlet equal or greater to the design static pressure plus 2-inch wg (500 Pa), **as directed**. Include slab height in trap calculation.

B. Shop-Fabricated Casings
1. Single- and Double-Wall Casings: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
2. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
   OR
   Double-Wall Casing Inner Panel: Solid sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
3. Interstitial Insulation: Polyurethane foam complying with NFPA 90A or NFPA 90B.
   OR
   Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
   b. Coat insulation with antimicrobial coating.
   c. Cover insulation with polyester film complying with UL 181, Class 1.
   OR
   Interstitial Insulation: Flexible-elastomeric duct liner complying with ASTM C 534, Type II for sheet materials and with NFPA 90A or NFPA 90B.
   a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
4. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.
5. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use galvanized sheet steel of same thickness as casing and with a galvanized coating designation of G90 (Z275).
6. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.
7. Reinforce casings with galvanized-steel angles.

C. Manufactured Casings
1. Description: Double-wall, insulated, pressurized equipment casing.
2. Double-Wall Panel Fabrication: Solid, galvanized sheet steel exterior wall and solid **OR** perforated, **as directed**, galvanized sheet steel interior wall; with space between wall filled with insulation.

a. Wall Thickness: 2 inches (50 mm) **OR** 4 inches (100 mm), **as directed**.
b. Fabricate with a minimum number of joints.
c. Weld exterior and interior walls to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
d. Sheet metal thickness shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.
OR
Sheet Metal Thicknesses:
1) Exterior Wall Thickness: 0.040 inch (1.0 mm) minimum.
2) Interior Wall Thickness: 0.034 inch (0.85 mm) minimum.
e. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having 3/32-inch-(2.4-mm-) diameter perforations, with overall open area of 23 percent.
OR
Double-Wall Casing Inner Panel: Solid sheet steel.
f. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant and vermin proof and that complies with NFPA 90A.
g. Fabricate panels with continuous tongue-and-groove **OR** self-locking, **as directed**, joints effective inside and outside each panel.

3. Trim Items: Fabricate from a minimum of 0.052-inch (1.3-mm) galvanized sheet steel, furnished in standard lengths for field cutting.

D. Casing Liner

1. Fibrous-Glass Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
a. Maximum Thermal Conductivity:
1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.
b. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
c. Solvent **OR** Water, **as directed**,-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Flexible-Elastomeric Casing Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1, and with NFPA 90A or NFPA 90B.
a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
b. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Natural-Fiber Casing Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor, and complying with NFPA 90A or NFPA 90B.
a. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature when tested according to ASTM C 518.
b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

4. Insulation Pins and Washers:
   a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) **OR** 0.135-inch- (3.5-mm-), **as directed**, diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   b. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized **OR** stainless, **as directed**, steel, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
5. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
   a. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing liner is prohibited.
   b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
   c. Butt transverse joints without gaps, and coat joint with adhesive.
   d. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
   e. Apply adhesive coating on longitudinal seams in casings with air velocity of 2500 fpm (12.7 m/s).
   f. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) longitudinally.
   g. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
      1) Fan discharges.
      2) Intervals of lined casing preceding unlined duct.
      3) Upstream edges of transverse joints in casings where air velocities are higher than 2500 fpm (12.7 m/s) or where indicated.
   h. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.

E. Sealant Materials
1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
2. Water-Based Joint and Seam Sealant:
   a. Application Method: Brush on.
   b. Solids Content: Minimum 65 percent.
   c. Shore A Hardness: Minimum 20.
   d. Water resistant.
   e. Mold and mildew resistant.
   f. VOC: Maximum 75 g/L (less water).
      OR
      For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   g. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
   h. Service: Indoor or outdoor.
   i. Substrate: Compatible with galvanized sheet steel or stainless steel.
3. Solvent-Based Joint and Seam Sealant:
   a. Application Method: Brush on.
   b. Base: Synthetic rubber resin.
   c. Solvent: Toluene and heptane.
   d. Solids Content: Minimum 60 percent.

e. Shore A Hardness: Minimum 60.
f. Water resistant.
g. Mold and mildew resistant.
h. VOC: Maximum 395 g/L.
OR
For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
i. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
j. Service: Indoor or outdoor.
k. Substrate: Compatible with galvanized sheet steel or stainless steel.

4. Flanged Joint Sealant: Comply with ASTM C 920.
   a. General: Single component, acid curing, silicone, elastomeric.
   b. Type: S.
   c. Grade: NS.
   d. Class: 25.
   e. Use: O.
   f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

1.3 EXECUTION

A. Installation
1. Install casings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Equipment Mounting: Install HVAC casings on concrete base. Comply with requirements for concrete base specified in Division 07 Section "Roof Expansion Assemblies".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported casings, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install seismic restraints on casings. Comply with requirements for seismic-restraint devices specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment"
4. Apply sealant to joints, connections, and mountings.
5. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
6. Support casings on floor or foundation system. Secure and seal to base.
7. Support components rigidly with ties, braces, brackets, seismic restraints, **as directed**, and anchors of types that will maintain housing shape and prevent buckling.
8. Align casings accurately at connections, with 1/8-inch (3-mm) misalignment tolerance and with smooth interior surfaces.

B. Field Quality Control
1. Tests and Inspections:
   a. Perform field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual."
   b. Test the following systems:
      1) Systems required by ASHRAE/IESNA 90.1-2004.
      2) Supply Air: 100 **OR** 50, **as directed**, percent of total installed duct area with a pressure class of 3-inch wg (750 Pa) **OR** 4-inch wg (1000 Pa), **as directed**, or higher.

c. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.

d. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.

e. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

2. HVAC casings will be considered defective if they do not pass tests and inspections.

3. Prepare test and inspection reports.

C. Cleaning

1. Comply with requirements for cleaning in Division 15 Section "Metal Ducts".

END OF SECTION 15840c

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SECTION 15840d - DUCT ACCESSORIES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for duct accessories. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section Includes:
   a. Backdraft and pressure relief dampers.
   b. Barometric relief dampers.
   c. Manual volume dampers.
   d. Control dampers.
   e. Fire dampers.
   f. Ceiling dampers.
   g. Smoke dampers.
   h. Combination fire and smoke dampers.
   i. Corridor dampers.
   j. Flange connectors.
   k. Duct silencers.
   l. Turning vanes.
   m. Remote damper operators.
   n. Duct-mounted access doors.
   o. Flexible connectors.
   p. Flexible ducts.
   q. Duct security bars.
   r. Duct accessory hardware.

C. Submittals

1. Product Data: For each type of product indicated.
   a. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.
2. LEED Submittal:
   a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
   a. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
      1) Special fittings.
      2) Manual volume damper installations.
      3) Control damper installations.
      4) Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
      5) Duct security bars.
      6) Wiring Diagrams: For power, signal, and control wiring.
4. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

5. Source quality-control reports.
6. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

D. Quality Assurance
1. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
2. Comply with AMCA 500-D testing for damper rating.

1.2 PRODUCTS

A. Materials
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   a. Galvanized Coating Designation: G60 (Z180) **OR** G90 (Z275),**as directed**.
   b. Exposed-Surface Finish: Mill phosphatized.
3. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and <**Insert finish designation**> finish for exposed ducts.
4. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
5. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.
6. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
7. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

B. Backdraft And Pressure Relief Dampers
1. Description: Gravity balanced.
2. Maximum Air Velocity: 2000 fpm (10 m/s) **OR** 3000 fpm (15 m/s), **as directed**.
3. Maximum System Pressure: 1-inch wg (0.25 kPa) **OR** 2-inch wg (0.5 kPa), **as directed**.
4. Frame: 0.052-inch- (1.3-mm-) thick, galvanized sheet steel **OR** 0.063-inch- (1.6-mm-) thick extruded aluminum **OR** 0.052-inch- (1.3-mm-) thick stainless steel, **as directed**, with welded corners and mounting flange, **as directed**.
5. Blades: Multiple single-piece blades, center-pivoted, **as directed**, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum **OR** 0.050-inch- (1.2-mm-) thick aluminum sheet **OR** noncombustible, tear-resistant, neoprene-coated fiberglass, **as directed**, with sealed edges.
6. Blade Action: Parallel.
7. Blade Seals: Felt **OR** Vinyl foam **OR** Extruded vinyl, mechanically locked **OR** Neoprene, mechanically locked, **as directed**.
8. Blade Axles:
   a. Material: Nonferrous metal **OR** Galvanized steel **OR** Plated steel **OR** Stainless steel **OR** Non-metallic **OR** Aluminum, **as directed**.
   b. Diameter: 0.20 inch (5 mm).
9. Tie Bars and Brackets: Aluminum **OR** Galvanized steel, **as directed**.
10. Return Spring: Adjustable tension.
11. Bearings: Steel ball **OR** Synthetic pivot bushings **OR** Steel ball or synthetic pivot bushings, **as directed**.
12. Accessories:
   a. Adjustment device to permit setting for varying differential static pressure.
   b. Counterweights and spring-assist kits for vertical airflow installations.

c. Electric actuators.
d. Chain pulls.
e. Screen Mounting: Front mounted in sleeve.
   1) Sleeve Thickness: 20-gage (1.0-mm) minimum.
   2) Sleeve Length: 6 inches (152 mm) minimum.
   OR
   Screen Mounting: Rear mounted.
f. Screen Material: Galvanized steel **OR** Aluminum, **as directed**.
g. Screen Type: Bird **OR** Insect, **as directed**.
h. 90-degree stops.

C. Barometric Relief Dampers
1. Suitable for horizontal or vertical mounting.
2. Maximum Air Velocity: 2000 fpm (10 m/s) **OR** 2500 fpm (13 m/s), **as directed**.
3. Maximum System Pressure: 2-inch wg (0.5 kPa).
4. Frame: 0.064-inch- (1.6-mm-) thick, galvanized sheet steel **OR** 0.063-inch- (1.6-mm-) thick extruded aluminum, **as directed**, with welded corners and mounting flange, **as directed**.
5. Blades:
   a. Multiple, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum **OR** 0.050-inch- (1.2-mm-) thick aluminum sheet, **as directed**.
   b. Maximum Width: 6 inches (150 mm).
   c. Action: Parallel.
   d. Balance: Gravity.
   e. Eccentrically pivoted.
6. Blade Seals: Vinyl **OR** Neoprene, **as directed**.
7. Blade Axles: Galvanized steel **OR** Nonferrous metal, **as directed**.
8. Tie Bars and Brackets:
   a. Material: Aluminum **OR** Galvanized steel, **as directed**.
   b. Rattle free with 90-degree stop.
9. Return Spring: Adjustable tension.
10. Bearings: Synthetic **OR** Stainless steel **OR** Bronze, **as directed**.
11. Accessories:
   a. Flange on intake.
   b. Adjustment device to permit setting for varying differential static pressures.

D. Manual Volume Dampers
1. Standard, Steel, Manual Volume Dampers:
   a. Standard leakage rating, with linkage outside airstream, **as directed**.
   b. Suitable for horizontal or vertical applications.
   c. Frames:
      1) Hat-shaped, galvanized-steel **OR** stainless-steel, **as directed**, channels, 0.064-inch (1.62-mm) minimum thickness.
      2) Mitered and welded corners.
      3) Flanges for attaching to walls and flangeless frames for installing in ducts.
   d. Blades:
      1) Multiple or single blade.
      2) Parallel- or opposed-blade design.
      3) Stiffen damper blades for stability.
      4) Galvanized-steel **OR** Stainless-steel, **as directed**, 0.064 inch (1.62 mm) thick.
   e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
   f. Bearings:
      1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
      2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   g. Tie Bars and Brackets: Galvanized steel.

2. Standard, Aluminum, Manual Volume Dampers:
   a. Standard leakage rating, with linkage outside airstream, **as directed**.
   b. Suitable for horizontal or vertical applications.
   c. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
   d. Blades:
      1) Multiple or single blade.
      2) Parallel- or opposed-blade design.
      3) Stiffen damper blades for stability.
      4) Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
         OR
         Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
   e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
   f. Bearings:
      1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
      2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   g. Tie Bars and Brackets: Aluminum.
3. Low-Leakage, Steel, Manual Volume Dampers:
   a. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
   b. Suitable for horizontal or vertical applications.
   c. Frames:
      1) Hat **OR** U **OR** Angle, **as directed**, shaped.
      2) Galvanized-steel **OR** Stainless-steel, **as directed**, channels, 0.064 inch (1.62 mm) thick.
      3) Mitered and welded corners.
      4) Flanges for attaching to walls and flangeless frames for installing in ducts.
   d. Blades:
      1) Multiple or single blade.
      2) Parallel- or opposed-blade design.
      3) Stiffen damper blades for stability.
      4) Galvanized **OR** Stainless, **as directed**, roll-formed steel, 0.064 inch (1.62 mm) thick.
   e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
   f. Bearings:
      1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
      2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
   g. Blade Seals: Felt **OR** Vinyl **OR** Neoprene, **as directed**.
   h. Jamb Seals: Cambered stainless steel **OR** aluminum, **as directed**.
   i. Tie Bars and Brackets: Galvanized steel **OR** Aluminum, **as directed**.
   j. Accessories:
      1) Include locking device to hold single-blade dampers in a fixed position without vibration.
4. Low-Leakage, Aluminum, Manual Volume Dampers:
   a. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
   b. Suitable for horizontal or vertical applications.
   c. Frames: Hat **OR** U **OR** Angle, **as directed**,-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
   d. Blades:
      1) Multiple or single blade.

2) Parallel- or opposed-blade design.
3) Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
OR
Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.

f. Bearings:
1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

g. Blade Seals: Felt **OR** Vinyl **OR** Neoprene, **as directed**.

h. Jamb Seals: Cambered stainless steel **OR** aluminum, **as directed**.

i. Tie Bars and Brackets: Galvanized steel **OR** Aluminum, **as directed**.

j. Accessories:
1) Include locking device to hold single-blade dampers in a fixed position without vibration.

5. Jackshaft:
a. Size: 1-inch (25-mm) diameter.
b. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
c. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

6. Damper Hardware:
a. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
b. Include center hole to suit damper operating-rod size.
c. Include elevated platform for insulated duct mounting.

E. Control Dampers
1. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
2. Frames:
a. Hat **OR** U **OR** Angle, **as directed**, shaped.
b. Galvanized-steel **OR** Stainless-steel, **as directed**, channels, 0.064 inch (1.62 mm) thick.
c. Mitered and welded corners.
3. Blades:
a. Multiple blade with maximum blade width of 8 inches (200 mm).
b. Parallel **OR** Parallel- and opposed **OR** Opposed, **as directed**,-blade design.
c. Galvanized **OR** Stainless, **as directed**, steel.
d. 0.064 inch (1.62 mm) thick.
e. Blade Edging: Closed-cell neoprene edging.
OR
Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
4. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel **OR** stainless steel **OR** nonferrous metal, **as directed**; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
a. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
5. Bearings:
a. Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
c. Thrust bearings at each end of every blade.

F. Fire Dampers

1. Type: Static **OR** Dynamic **OR** Static and dynamic, **as directed**; rated and labeled according to UL 555 by an NRTL.
2. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.
3. Fire Rating: 1-1/2 **OR** 3, **as directed**, hours.
4. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
5. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   a. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) thick, as indicated, and of length to suit application.
   b. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
6. Mounting Orientation: Vertical or horizontal as indicated.
7. Blades: Roll-formed, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
8. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
9. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
   OR
   Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated.

G. Ceiling Dampers
1. General Requirements:
   a. Labeled according to UL 555C by an NRTL.
   b. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
2. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.
3. Blades: Galvanized sheet steel with refractory insulation.
4. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
5. Fire Rating: 2 **OR** 3, **as directed**, hours.

H. Smoke Dampers
1. General Requirements: Label according to UL 555S by an NRTL.
2. Smoke Detector: Integral, factory wired for single-point connection.
3. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
4. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
5. Leakage: Class I **OR** Class II, **as directed**.
6. Rated pressure and velocity to exceed design airflow conditions.
7. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking, **as directed**.
8. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
9. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15 Section(s) "Hvac Instrumentation And Controls", **as directed**.
c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
g. Electrical Connection: 115 V, single phase, 60 Hz.

10. Accessories:
    a. Auxiliary switches for signaling **OR** fan control **OR** position indication, **as directed**.
    b. Momentary test switch **OR** Test and reset switches, **as directed**, damper **OR** remote, **as directed**, mounted.

I. Combination Fire And Smoke Dampers
1. Type: Static **OR** Dynamic **OR** Static and dynamic, **as directed**; rated and labeled according to UL 555 and UL 555S by an NRTL.
2. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.
3. Fire Rating: 1-1/2 **OR** 3, **as directed**, hours.
4. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
5. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
   OR
   Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, rated.
6. Smoke Detector: Integral, factory wired for single-point connection.
7. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
8. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
9. Leakage: Class I **OR** Class II, **as directed**.
10. Rated pressure and velocity to exceed design airflow conditions.
11. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking, **as directed**.
12. Master control panel for use in dynamic smoke-management systems.
13. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
14. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15 Section(s) "Hvac Instrumentation And Controls", **as directed**.
c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
g. Electrical Connection: 115 V, single phase, 60 Hz.

15. Accessories:
a. Auxiliary switches for signaling **OR** fan control **OR** position indication, **as directed**.
b. Momentary test switch **OR** Test and reset switches, **as directed**, damper **OR** remote, **as directed**, mounted.

J. Corridor Dampers
1. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-1/2-hour rating by an NRTL.
2. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) **OR** 212 deg F (100 deg C), **as directed**, rated, fusible links.
OR
Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, rated.
3. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
4. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
5. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
6. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
7. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15 Section(s) "Hvac Instrumentation And Controls", **as directed**.
c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
g. Electrical Connection: 115 V, single phase, 60 Hz.

K. Flange Connectors
1. Description: Add-on **OR** Roll-formed, **as directed**, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
2. Material: Galvanized steel.
3. Gage and Shape: Match connecting ductwork.

L. Duct Silencers
1. General Requirements:
a. Factory fabricated.
b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
2. Shape:
a. Rectangular straight with splitters or baffles.
b. Round straight with center bodies or pods.
c. Rectangular elbow with splitters or baffles.
d. Round elbow with center bodies or pods.
e. Rectangular transitional with splitters or baffles.
3. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275) **OR** G60 (Z180), **as directed**, galvanized sheet steel, 0.034 inch (0.85 mm) **OR** 0.040 inch (1.02 mm), **as directed**, thick.
4. Round Silencer Outer Casing: ASTM A 653/A 653M, G90 (Z275) **OR** G60 (Z180), **as directed**, galvanized sheet steel.
a. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.
b. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.
c. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.052 inch (1.3 mm) thick.
d. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.
5. Inner Casing and Baffles: ASTM A 653/A 653M, G90 (Z275) **OR** G60 (Z180), **as directed**, galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.
6. Special Construction:
a. Suitable for outdoor use.
b. High transmission loss to achieve STC 45, **as directed**.
7. Connection Sizes: Match connecting ductwork unless otherwise indicated.
8. Principal Sound-Absorbing Mechanism:
a. Controlled impedance membranes and broadly tuned resonators without absorptive media.
b. Dissipative **OR** Film-lined, **as directed**, type with fill material.
1) Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression **OR** Inert and vermin-proof fibrous material, packed under not less than 15 percent compression **OR** Moisture-proof nonfibrous material, **as directed**.
2) Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

c. Lining: None **OR** Mylar **OR** Tedlar **OR** Fiberglas cloth, **as directed**.

9. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
   a. Lock form and seal or continuously weld joints **OR** Flange connections, **as directed**.
   b. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   c. Reinforcement: Cross or trapeze angles for rigid suspension.
10. Accessories:
   a. Integral 1-1/2 **OR** 3, **as directed**,-hour fire damper with access door. Access door to be high transmission loss to match silencer, **as directed**.
   b. Factory-installed end caps to prevent contamination during shipping.
   c. Removable splitters.
   d. Airflow measuring devices.
   e. Source Quality Control: Test according to ASTM E 477.
   f. Testing to be witnessed by Owner.
   g. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.
   h. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

M. Turning Vanes
1. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
   a. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
2. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
3. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
4. Vane Construction: Single **OR** Double, **as directed**, wall.
   OR
   Vane Construction: Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

N. Remote Damper Operators
1. Description: Cable system designed for remote manual damper adjustment.
2. Tubing: Brass.
3. Cable: Stainless steel.
4. Wall-Box Mounting: Recessed, 3/4 inches (19 mm) deep **OR** Recessed, 2 inches (50 mm) deep **OR** Surface, **as directed**.
5. Wall-Box Cover-Plate Material: Steel **OR** Stainless steel, **as directed**.

O. Duct-Mounted Access Doors
1. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
   a. Door:
      1) Double wall, rectangular.
      2) Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      3) Vision panel.
      4) Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
      5) Fabricate doors airtight and suitable for duct pressure class.

b. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
c. Number of Hinges and Locks:
1) Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
2) Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
3) Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles, **as directed**.
4) Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2. Pressure Relief Access Door:
a. Door and Frame Material: Galvanized sheet steel.
b. Door: Single wall **OR** Double wall with insulation fill, **as directed**, with metal thickness applicable for duct pressure class.
c. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
d. Factory set at 10-inch wg (2500 Pa).
e. Doors close when pressures are within set-point range.
f. Hinge: Continuous piano.
g. Latches: Cam.
h. Seal: Neoprene or foam rubber.
i. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

P. Duct Access Panel Assemblies
1. Labeled according to UL 1978 by an NRTL.
2. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon **OR** 0.0428-inch (1.1-mm) stainless, **as directed**, steel.
3. Fasteners: Carbon **OR** Stainless, **as directed**, steel. Panel fasteners shall not penetrate duct wall.
4. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
5. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

Q. Flexible Connectors
1. Materials: Flame-retardant or noncombustible fabrics.
2. Coatings and Adhesives: Comply with UL 181, Class 1.
3. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) **OR** 5-3/4 inches (146 mm), **as directed**, wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
4. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
a. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
b. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
c. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
5. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
a. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
b. Minimum Tensile Strength: 500 lbf/inch (88 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
c. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
6. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
a. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
b. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
c. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

7. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
   a. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
   b. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
   c. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
8. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
   a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
   b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
   f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
   g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

R. Flexible Ducts
1. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
   a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
2. Noninsulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.
   a. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
3. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
   a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Noninsulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.
   a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
5. Noninsulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil.
   a. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
   b. Maximum Air Velocity: 5000 fpm (25 m/s).
   c. Temperature Range: Minus 100 to plus 435 deg F (Minus 73 to plus 224 deg C).
6. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
   a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
   d. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2004.
7. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.

a. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
b. Maximum Air Velocity: 4000 fpm (20 m/s).
c. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
d. Insulation R-Value: Comply with ASHRAE/IESNA 90.1-2004.

8. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
   a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
   d. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2004.
9. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
   a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   b. Maximum Air Velocity: 4000 fpm (20 m/s).
   c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
   d. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2004.
10. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
    a. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
    b. Maximum Air Velocity: 5000 fpm (25 m/s).
    c. Temperature Range: Minus 20 to plus 250 deg F (Minus 29 to plus 121 deg C).
    d. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2004.
11. Flexible Duct Connectors:
    a. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action **OR** Nylon strap, **as directed**, in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
    b. Non-Clamp Connectors: Adhesive **OR** Liquid adhesive plus tape **OR** Adhesive plus sheet metal screws, **as directed**.

S. Duct Security Bars
1. Description: Field-fabricated **OR** Factory-fabricated and field-installed **OR** Field- or factory-fabricated and field-installed, **as directed**, duct security bars.
2. Configuration:
   a. Frame: 10 gage by 2 inches (3.57 mm by 50 mm).
   b. Sleeve: 3/16-inch (4.8-mm), continuously welded **OR** bent, **as directed**, steel frames with 1-by-1-by-3/16-inch (25-by-25-by-4.8-mm) angle frame factory welded to 1 end **OR** furnished loose for field welding on other end, **as directed**. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
   c. Horizontal Bars: 1/2 inch (13 mm) **OR** 2 by 1/4 inch (50 by 6 mm), **as directed**.
   d. Vertical Bars: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
   e. Bar Spacing: 6 inches (150 mm).
   f. Mounting: Metal deck or roofing **OR** Bolted or welded **OR** Bolted or welded with masonry anchors **OR** Ductwork or other framing **OR** Poured in place or set with concrete block **OR** Welded or bolted to one wall (one side only) **OR** Bar extends 6 inches (150 mm) into wall, **as directed**.

T. Duct Accessory Hardware
1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

1.3 EXECUTION

A. Installation
1. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
2. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
3. Install backdraft **OR** control, **as directed**, dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
4. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
   a. Install steel volume dampers in steel ducts.
   b. Install aluminum volume dampers in aluminum ducts.
5. Set dampers to fully open position before testing, adjusting, and balancing.
6. Install test holes at fan inlets and outlets and elsewhere as indicated.
7. Install fire and smoke, **as directed**, dampers according to UL listing.
8. Install duct security bars. Construct duct security bars from 0.164-inch (4.18-mm) steel sleeve, continuously welded at all joints and 1/2-inch- (13-mm-) diameter steel bars, 6 inches (150 mm) o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) hinged access panel with cam lock in duct in each side of sleeve.
9. Connect ducts to duct silencers with flexible duct connectors **OR** rigidly, **as directed**.
10. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
    a. On both sides of duct coils.
    b. Upstream **OR** Upstream and downstream, **as directed**, from duct filters.
    c. At outdoor-air intakes and mixed-air plenums.
    d. At drain pans and seals.
    e. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
    f. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
    g. At each change in direction and at maximum 50-foot (15-m) spacing.
    h. Upstream **OR** Upstream and downstream, **as directed**, from turning vanes.
    i. Upstream or downstream from duct silencers.
    j. Control devices requiring inspection.
    k. Elsewhere as indicated.
11. Install access doors with swing against duct static pressure.
12. Access Door Sizes:
    a. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
    b. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
    c. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
    d. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
    e. Body Access: 25 by 14 inches (635 by 355 mm).
    f. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
13. Label access doors according to Division 15 Section "Fire-suppression Systems Insulation" to indicate the purpose of access door.
14. Install flexible connectors to connect ducts to equipment.

15. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
16. Connect terminal units to supply ducts directly or, **as directed**, with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
17. Connect diffusers or light troffer boots to ducts directly or, **as directed**, with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
18. Connect flexible ducts to metal ducts with adhesive **OR** liquid adhesive plus tape **OR** draw bands **OR** adhesive plus sheet metal screws, **as directed**.
19. Install duct test holes where required for testing and balancing purposes.
20. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

B. Field Quality Control
1. Tests and Inspections:
   a. Operate dampers to verify full range of movement.
   b. Inspect locations of access doors and verify that purpose of access door can be performed.
   c. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
   d. Inspect turning vanes for proper and secure installation.
   e. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 15840d

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Task	Specification	Specification Description
15848	01352	No Specification Required
15848	15840a	Metal Ducts
15848	15840c	HVAC Casings
15851	15840	Tailpipe Exhaust Equipment

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SECTION 15855 - BREECHINGS, CHIMNEYS, AND STACKS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for breechings, chimneys, and stacks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Listed chimney liners.
b. Listed single-wall and double-wall vents and chimneys.
c. Listed, refractory-lined breechings and stacks.
d. Field-fabricated metal breechings and chimneys.
e. Listed grease and dishwasher ducts.

C. Submittals
1. Product Data: For the following:
a. Chimney liners.
b. Type B and BW vents.
c. Type L vents.
d. Special gas vents.
e. Building-heating-appliance chimneys.
f. Grease ducts.
g. Refractory-lined metal breechings and chimneys.
h. Guy wires and connectors.
2. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
3. Welding certificates.
4. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Warranty: Warranty specified in this Section.

D. Quality Assurance
1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

E. Warranty
1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within 10 **OR** 15 **OR** 25, **as directed**, years from date of Substantial Completion. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1.2 PRODUCTS

A. Listed Chimney Liners
1. Description: Straight **OR** Corrugated, **as directed**, single-wall chimney liner tested according to UL 1777 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with negative or positive flue pressure complying with NFPA 211.

2. Straight Liner Materials: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
3. Corrugated Liner Materials: ASTM A 240/A 240M, Type 321 **OR** ASTM A 240/A 240M, Type 430 **OR** ASTM A 959, Type 29-4C, **as directed**, stainless steel.
4. Accessories:
   a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
   b. Sealant: Manufacturer's standard high-temperature sealant.
   c. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.

B. Listed Type B And BW Vents
1. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B, or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.
2. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
3. Inner Shell: ASTM B 209 (ASTM B 209M), Type 1100 aluminum **OR** ASTM B 209 (ASTM B 209M), Type 3003 aluminum **OR** ASTM B 209 (ASTM B 209M), Type 3105 aluminum **OR** ASTM A 666, Type 430 stainless steel, **as directed**.
4. Outer Jacket: Galvanized **OR** Aluminized, **as directed**, steel.
5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   a. Termination:
      1) Stack cap designed to exclude minimum 90 percent of rainfall.
      OR
      Round chimney top designed to exclude minimum 98 percent of rainfall.
      OR
      Exit cone with drain section incorporated into riser.
      OR
      Antibackdraft.

C. Listed Type L Vents
1. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
2. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) **OR** 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 4-inch (100-mm), **as directed**, airspace filled with high-temperature, ceramic-fiber **OR** mineral-wool, **as directed**, insulation.
3. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
4. Outer Jacket: Galvanized **OR** Aluminized **OR** Stainless, **as directed**, steel.
5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   a. Termination:
      1) Stack cap designed to exclude 90 percent of rainfall.
      OR
      Round chimney top designed to exclude 98 percent of rainfall.
      OR
      Exit cone with drain section incorporated into riser.

D. Listed Special Gas Vents
1. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.

2. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.
3. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
4. Outer Jacket: Aluminized **OR** Stainless, **as directed**, steel.
5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   a. Termination:
      1) Stack cap designed to exclude minimum 90 percent of rainfall.
      OR
      Round chimney top designed to exclude minimum 98 percent of rainfall.
      OR
      Exit cone with drain section incorporated into riser.

E. Listed Building-Heating-Appliance Chimneys
1. Description for building-heating-appliance chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
   a. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (25-mm) **OR** 1-inch (50-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation, **as directed**.
   b. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
2. Description for 1400 deg F (760 deg C) chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F (760 deg C) continuously, or 1800 deg F (982 deg C) for 10 minutes; with positive or negative flue pressure complying with NFPA 211.
   a. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
   b. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
3. Description for Type HT chimneys suitable for fireplaces and other solid-fuel-burning appliances: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
   a. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 1-1/2-inch (38-mm) **OR** 2-inch (50-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
   b. Inner Shell: ASTM A 666, Type 304 **OR** ASTM A 666, Type 316 **OR** ASTM A 240/A 240M, Type 430, **as directed**, stainless steel.
4. Outer Jacket: Galvanized **OR** Aluminized **OR** Stainless, **as directed**, steel.
5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   a. Termination:
      1) Stack cap designed to exclude minimum 90 percent of rainfall.
      OR
      Round chimney top designed to exclude minimum 98 percent of rainfall.
      OR
      Exit cone with drain section incorporated into riser.

F. Listed Grease Ducts
1. Description: Double-wall metal vents tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

2. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
3. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
4. Outer Jacket: Aluminized **OR** Stainless, **as directed**, steel where concealed. Stainless steel where exposed.
5. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.

G. Listed, Refractory-Lined Metal Breechings And Chimneys
1. Comply with ASME STS-1.
2. Design Wind Loads: 150 mph (241 km/h), **as directed**.
3. Design for seismic conditions at Project site.
4. Chimney Outer Jacket: Aluminized **OR** Galvanized, **as directed**, steel with riveted **OR** welded, **as directed**, seams.
5. Refractory Lining: Tested according to UL 959 for temperature and acid resistance, and bearing the testing laboratory label.
   a. Temperature Rating: 1800 deg F (982 deg C) continuously, and 2000 deg F (1093 deg C) intermittently.
   b. Acid Extraction: Maximum of 0.2 percent.
   c. Cold Crushing Strength: Minimum of 3200 psig (22 MPa).
   d. Thickness: Minimum of 2 inches (50 mm).
6. Finish: Factory-applied, high-heat-resistant paint; color as selected.
7. Base Section: Acid-resistant-coated, cast-iron anchor lugs for securing stack to foundation with anchorage designed by manufacturer, **as directed**.
8. Reinforced Cleanout Section: Smoke-tight connection, with gasketed and bolt-tightened inspection plate; neck shall be welded to stack section.
9. T or Y Sections: Smoke-tight connection, with welded joints and refractory lining; finished with smooth transition and with no exposed metal on inside.
10. Spark Screen: ASTM A 666, Type 316 stainless steel, 0.0625 inch (1.6 mm) thick, maximum 1/2-by-1/2-inch (13-by-13-mm) mesh, with ASTM A 666, Type 304 stainless-steel rolled angle and drawband.
11. Guy Bands: 8-inch- (200-mm-) wide bands of same material as jacket, with bolted fasteners.
12. Roof Penetration: Factory-fabricated thimbles, flashings, and counterflashings.
13. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.
14. Fabricate components with centrifugally cast refractory lining in lengths suitable for connection with drawbands.
15. Bond refractory to steel jacket with calcium aluminate cement to prevent separation in finished product during shipping, handling, and installation.
16. Fabricate stacks with anchor lugs; cleanout; T sections; flashings and counterflashings; and provisions for support, expansion, and contraction.

H. Field-Fabricated Metal Breechings And Chimneys
1. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction."
2. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.
   a. Equal to or Less Than 1.069 Sq. Ft. (0.099 Sq. m.) or 14 Inches (356 mm) in Diameter: 0.053 inch (1.35 mm).
   b. Up to 1.396 Sq. Ft. (0.129 Sq. m) or 16 Inches (406 mm) in Diameter: 0.067 inch (1.7 mm).

c. Up to 1.764 Sq. Ft. (0.164 Sq. m.) or 18 Inches (457 mm) in Diameter: 0.093 inch (2.36 mm).
d. Larger Than Above: 0.123 inch (3.12 mm).

3. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.
   a. Equal to or Less Than 6 Inches (152 mm) in Diameter: 0.019 inch (0.48 mm).
   b. Up to 10 Inches (254 mm) in Diameter: 0.024 inch (0.61 mm).
   c. Up to 16 Inches (406 mm) in Diameter: 0.029 inch (0.74 mm).
   d. Larger Than Above: 0.056 inch (1.42 mm).
4. Fabricate chimneys and vent connectors from ASTM B 209 (ASTM B 209M), Type 1100 or 3003, aluminum or stainless steel, complying with NFPA 211 for the following minimum metal thicknesses:
   a. Aluminum: 0.027 inch (0.69 mm).
   b. Stainless Steel: 0.012 inch (0.31 mm).
5. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.
6. Fabricate engine exhaust from ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** Schedule 80, **as directed**, pipe; with welded joints and carbon-steel fittings and flanges.
   a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
   b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.

I. Guying And Bracing Materials
1. Cable: Three **OR** Four, **as directed**, galvanized, stranded wires of the following thickness:
   a. Minimum Size: 1/4 inch (6 mm) in diameter.
   b. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).
   c. For ID Sizes 18 to 24 Inches (457 to 610 mm): 3/8 inch (9.5 mm).
   d. For ID Sizes 27 to 30 Inches (685 to 762 mm): 7/16 inch (11 mm).
   e. For ID Sizes 33 to 36 Inches (838 to 915 mm): 1/2 inch (13 mm).
   f. For ID Sizes 39 to 48 Inches (990 to 1220 mm): 9/16 inch (14.3 mm).
   g. For ID Sizes 51 to 60 Inches (1295 to 1524 mm): 5/8 inch (16 mm).
2. Pipe: Two **OR** Three, **as directed**, galvanized steel, NPS 1-1/4 (DN 32).
3. Angle Iron: Two **OR** Three, **as directed**, galvanized steel, 2 by 2 by 0.25 inch (50 by 50 by 6 mm).

1.3 EXECUTION

A. Application
1. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.
2. Listed Type B and BW Vents: Vents for certified gas appliances.
3. Listed Type L Vents: Vents for low-heat appliances.
4. Listed Special Gas Vents: Condensing gas appliances.
5. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.
6. Listed Grease Ducts: Type I commercial kitchen grease duct.
7. Listed, Refractory-Lined Metal Breechings and Chimneys: Freestanding dual-fuel boiler vents, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
8. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
9. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

B. Installation Of Listed Vents And Chimneys

1. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
2. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
3. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
5. Lap joints in direction of flow.
6. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.
7. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
8. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

C. Installation Of Unlisted, Field-Fabricated Breechings And Chimneys
1. Suspend breechings and chimneys independent of their appliance connections.
2. Install, support, and restrain according to seismic requirements.
3. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch (3-mm) misalignment tolerance.
4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
5. Lap joints in direction of flow.
6. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

D. Cleaning
1. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
2. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
3. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 15855

Task	Specification	Specification Description
15860	15840d	Duct Accessories

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SECTION 15861 - DRAFT CONTROL DEVICES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for draft control devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Draft inducer fans.
b. Venturi-draft inducer fans.
c. Mechanical-draft vent fans.
d. Vent exhaust fans.
e. Barometric dampers.
f. Vent dampers.
g. Combustion-air fans.

C. Submittals
1. Product Data: For each type of product indicated.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and Maintenance Data.
4. Warranty: Warranty specified in this Section.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Warranty
1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, barometric dampers, vent dampers, and/or combustion-air fans that fail in materials or workmanship within two **OR** 10, **as directed**, years from date of Substantial Completion.
a. Failures include failure of the fan due to corrosion.

1.2 PRODUCTS

A. Draft Inducer Fans
1. Fan Construction: Galvanized **OR** Aluminized, **as directed**,-steel housing and radial-blade centrifugal fan.
a. Fan Motor: Permanent split-capacitor type.
2. Controls:
a. Draft proving switch.
b. Control kit to cycle fan with gas flow to a single burner.

B. Venturi-Draft Inducer Fans
1. Fan Construction: Enameled-steel venturi tube for vents 20 inches (508 mm) in diameter and smaller, and ASTM A 666, Type 304, stainless-steel venturi tube for vents 22 to 48 inches (559 to 1219 mm) in diameter. Galvanized **OR** Enameled, **as directed**,-steel fan housing with radial-blade centrifugal wheel.

a. Fan Motor: Permanent split-capacitor type.

2. Controls:
   a. Draft proving switch.
   b. Control kit to cycle fan with gas flow to a single burner.

C. Mechanical-Draft Vent Fans
1. Fan Construction: Forward-curved centrifugal fan and scroll fabricated of aluminized **OR** galvanized, **as directed**, steel; direct-drive, ball-bearing motor lubricated with synthetic oil; internal cooling fan; stainless-steel shaft; and integral pressure-sensing switch.
   a. Fan Motor: Permanent split-capacitor type.
2. Controls:
   a. Draft proving switch.
   b. Control kit to cycle fan with gas flow to single **OR** multiple, **as directed**, burner(s).
3. Accessories:
   a. Aluminized **OR** Stainless, **as directed**,-steel, wall-vent hood.

D. Vent Exhaust Fans
1. General: Centrifugal fan with variable **OR** constant, **as directed**,-speed control mounted at end of sidewall **OR** vertical, **as directed**, vent.
2. Test Standard: UL 378, for fans exposed to flue gases up to 640 deg F (337 deg C).
3. Fan Construction: Cast-aluminum **OR** Galvanized-steel **OR** Stainless-steel, **as directed**, housing painted manufacturer's standard color of baked enamel, **as directed**. Galvanized **OR** Stainless, **as directed**,-steel vent. Cast-aluminum **OR** Stainless-steel, **as directed**, wheel. Backward-inclined centrifugal or axial fan wheel statically and dynamically balanced. Provide access to clean the discharge area. Concentric makeup air inlet duct surrounding the vent to allow zero clearance to combustibles, **as directed**.
4. Motor: Fully enclosed, variable-speed duty, **as directed**, permanent split capacitor, out of the airstream, with prelubricated and sealed ball bearings.
5. Constant-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure switch permits burner operation via interlock with boiler. Fan proving switch is adjustable between minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa).
6. Variable-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure controller, control transformer, and miscellaneous controls for automatic modulation of fan speed to maintain preset negative pressure between 0- and minus 1.0-inch wg (0 and minus 249 Pa). Include controller with indicator lights, pressure differential transmitter, chimney pressure sensor probe, and fan proving switch adjustable between minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa). Include tubing.

E. Barometric Dampers
1. Damper Construction: High-temperature-enamel-painted steel damper and housing with galvanized-steel breeching connection. Adjustable counterweight with lock. Include knife-edge bearings that do not require lubrication.

F. Vent Dampers
1. Damper Construction: Stainless-steel damper blade, shaft, and vent pipe with metal, prelubricated bearings.
   a. Electric motor sized to power damper open and closed in approximately 15 seconds in each direction. Power is off when damper is at rest.
   b. Comply with ANSI Z21.66.
2. Controls:
   a. Control transformer.
   b. Keyed wiring harness.
   c. Damper end-switch to prove damper is open.
   d. Interlock with boiler to permit burner operation when damper is open.
   e. Hold-open switch for troubleshooting boiler controls.

G. Combustion-Air Fans
   1. Fan Construction: Galvanized **OR** Aluminized, **as directed**,-steel housing; steel forward-curved fan and scroll; direct-drive, totally enclosed, fan-cooled motor with ball bearings; stainless-steel shaft; and integral pressure-sensing switch.
      a. Internal bypass to temper supply-air temperature to room.
   2. Controls:
      a. Fan proving switch to permit burner operation when combustion-air fan is operating.
      b. Multiple appliance control starts fan with operation of any one of three **OR** four, **as directed**, appliances.
      c. Modulating combustion-air fan speed to control pressure differential in room with respect to outdoors.
      d. Manual-reset, high-limit switch stops operation with 160 deg F (71 deg C) room temperature.
      e. Optional Controls:
         1) Alarm circuit.
         2) Excessive negative pressure limit.
         3) Interface relay for vent exhaust fan, draft inducer fan, or mechanical-draft vent fan.
         4) Galvanized-steel **OR** Aluminum, **as directed**, intake hood.

H. Motors
   1. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation
   1. Install listed components in a manner complying with the listing.
   2. Secure barometric dampers to breechings with hardware compatible with connected materials.
   3. Locate barometric and motorized vent dampers as close to draft hood collar as possible.
   4. Secure barometric and motorized vent dampers to appliances, breechings, or chimneys with hardware compatible with connected materials.
   5. Install draft inducer fans in single-wall vent section that is designed to couple with other vent materials.
   6. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.
   7. Install draft inducer fans with clearances for service and maintenance.
   8. Install PVC, **as directed**, intake duct that is sized according to manufacturer's written instructions.

B. Connections
   1. Ground equipment according to Division 16 Section "Grounding And Bonding".
   2. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Startup Service
   1. Engage a factory-authorized service representative to perform startup service.
      a. Complete installation and startup checks according to manufacturer's written instructions.
   2. Remove and replace malfunctioning components and recheck.

D. Adjusting
   1. Set field-adjustable switches and controls as indicated.

E. Demonstration
   1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain draft control devices.

END OF SECTION 15861

Task	Specification	Specification Description
15861	15840d	Duct Accessories
15863	15840d	Duct Accessories
15864	15840d	Duct Accessories
15865	15840d	Duct Accessories
15866	15840d	Duct Accessories

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SECTION 15867 - DIFFUSERS, REGISTERS, AND GRILLES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for diffusers, registers and grilles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Round ceiling diffusers.
b. Rectangular and square ceiling diffusers.
c. Perforated diffusers.
d. Louver face diffusers.
e. Linear bar diffusers.
f. Linear slot diffusers.
g. Ceiling-integral continuous diffusers.
h. Light troffer diffusers.
i. Round induction diffusers.
j. Linear floor diffuser plenums.
k. Drum louvers.
l. Modular core supply grilles.
m. Continuous tubular diffusers.
n. Adjustable bar registers and grilles.
o. Security registers and grilles.
p. Fixed face registers and grilles.
q. Linear bar grilles.

C. Submittals
1. Product Data: For each type of product indicated, include the following:
a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
b. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
2. Samples: For each exposed product and for each color and texture specified.

1.2 PRODUCTS

A. Ceiling Diffusers
1. Round Ceiling Diffuser:
a. Devices shall be specifically designed for variable-air-volume flows.
b. Material: Steel **OR** Aluminum, **as directed**.
c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
d. Face Style: Four **OR** Three **OR** Two, **as directed**, cone.
e. Mounting: Duct connection.
f. Pattern: Fully adjustable **OR** Two-position horizontal, **as directed**.
g. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
h. Accessories:
1) Equalizing grid.

2) Plaster ring.
3) Safety chain.
4) Wire guard.
5) Sectorizing baffles.
6) Operating rod extension.

2. Rectangular and Square Ceiling Diffusers:
   a. Devices shall be specifically designed for variable-air-volume flows.
   b. Material: Steel **OR** Aluminum, **as directed**.
   c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
   d. Face Size: 24 by 24 inches (600 by 600 mm) **OR** 20 by 20 inches (500 by 500 mm) **OR** 12 by 12 inches (300 by 300 mm), **as directed**.
   e. Face Style: Three cone **OR** Four cone **OR** Plaque, **as directed**.
   f. Mounting: Surface **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
   g. Pattern: Fixed **OR** Two position **OR** Adjustable, **as directed**.
   h. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
   i. Accessories:
      1) Equalizing grid.
      2) Plaster ring.
      3) Safety chain.
      4) Wire guard.
      5) Sectorizing baffles.
      6) Operating rod extension.
3. Perforated Diffuser:
   a. Devices shall be specifically designed for variable-air-volume flows.
   b. Material: Steel backpan and pattern controllers, with steel **OR** aluminum, **as directed**, face.
   c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
   d. Face Size: 12 by 12 inches (300 by 300 mm) **OR** 24 by 12 inches (600 by 300 mm) **OR** 36 by 12 inches (900 by 300 mm) **OR** 48 by 12 inches (1200 by 300 mm) **OR** 16 by 16 inches (400 by 400 mm) **OR** 20 by 20 inches (500 by 500 mm) **OR** 24 by 24 inches (600 by 600 mm) **OR** 36 by 24 inches (900 by 600 mm) **OR** 48 by 24 inches (1200 by 600 mm), **as directed**.
   e. Duct Inlet: Round **OR** Square, **as directed**.
   f. Face Style: Flush **OR** Drop extended, **as directed**.
   g. Mounting: Surface **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
   h. Pattern Controller: Four louvered deflector patches **OR** Fixed with curved blades at inlet **OR** Adjustable with louvered pattern modules at inlet **OR** None, **as directed**.
   i. Dampers: Opposed blade **OR** Radial opposed blade **OR** Butterfly **OR** Combination damper and grid **OR** Combination volume and fire, **as directed**.
   j. Accessories:
      1) Equalizing grid.
      2) Plaster ring.
      3) Safety chain.
      4) Wire guard.
      5) Sectorizing baffles.
      6) Operating rod extension.
4. Louver Face Diffuser:
   a. Devices shall be specifically designed for variable-air-volume flows.
   b. Material: Steel **OR** Aluminum, **as directed**.
   c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
   d. Face Size: as directed by the Owner.

e. Mounting: Surface **OR** Surface with beveled frame **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
f. Pattern: One-way **OR** Two-way **OR** Two-way corner **OR** Three-way **OR** Four-way **OR** Adjustable, **as directed**, core style.
g. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
h. Accessories:
1) Square to round neck adaptor.
2) Adjustable pattern vanes.
3) Throw reducing vanes.
4) Equalizing grid.
5) Plaster ring.
6) Safety chain.
7) Wire guard.
8) Sectorizing baffles.
9) Operating rod extension.

B. Ceiling Linear Slot Outlets
1. Linear Bar Diffuser:
a. Devices shall be specifically designed for variable-air-volume flows.
b. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
c. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
d. Narrow Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/4 inch (6 mm) apart, zero **OR** 15, **as directed**,-degree deflection.
e. Wide Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/2 inch (13 mm) apart, zero **OR** 15, **as directed**,-degree deflection.
f. Wide Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 1/2 inch (13 mm) apart, zero **OR** 15 **OR** 30, **as directed**,-degree deflection.
g. Pencil-Proof Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 7/16 inch (11 mm) apart, zero **OR** 15 **OR** 30, **as directed**,-degree deflection.
h. One **OR** Two, **as directed**,-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
i. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm) **OR** 3/4 inch (19 mm) **OR** 1/2 inch (13 mm) **OR** 3/16 inch (5 mm), **as directed**, wide.
j. Mounting Frame: Filter.
k. Mounting: Countersunk screw **OR** Concealed bracket **OR** Spring clip, **as directed**.
l. Damper Type: Adjustable opposed-blade assembly **OR** Hinged single blade, **as directed**.
m. Accessories: Plaster frame **OR** Directional vanes **OR** Alignment pins **OR** Core clips **OR** Blank-off strips, **as directed**.
2. Linear Slot Diffuser:
a. Devices shall be specifically designed for variable-air-volume flows.
b. Material - Shell: Steel **OR** Aluminum, **as directed**, insulated **OR** noninsulated, **as directed**.
c. Material - Pattern Controller and Tees: Aluminum.
d. Finish - Face and Shell: Baked enamel, black.
e. Finish - Pattern Controller: Baked enamel, black.
f. Finish - Tees: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
g. Slot Width: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
h. Number of Slots: One **OR** Two **OR** Three **OR** Four, **as directed**.
i. Length: 24 inches (600 mm) **OR** 30 inches (750 mm) **OR** 36 inches (900 mm) **OR** 48 inches (1200 mm) **OR** 60 inches (1500 mm), **as directed**.
j. Accessories: Plaster frame **OR** T-bar slot **OR** Center notch **OR** T-bar on inlet side **OR** T-bar on both sides **OR** T-bar clip on one side **OR** T-bar clips on both sides, **as directed**.
3. Ceiling-Integral Continuous Diffuser:

a. Slot Width: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (50 mm) **OR** 2-1/2 inches (63 mm) **OR** 3 inches (76 mm), **as directed**.
b. Section Length: 12 feet (3.7 m).
c. Straight and curved sections as required to accommodate layout.
d. Mitered tees and corners.
e. Pattern Controllers: 24 inches (600 mm) o.c.
f. Material: Aluminum, extruded, heavy wall.
g. Finishes:
1) Exterior: Standard white.
2) Interior: Standard black.
h. Throw: Standard **OR** High, **as directed**.
i. Mounting: Ceiling **OR** Sidewall, **as directed**.
j. Plenum: Noninsulated **OR** Insulated, **as directed**.
k. Other Features:
1) Painted interior.
2) Blank-offs.

4. Light Troffer Diffuser:
a. Devices shall be specifically designed for variable-air-volume flows.
b. Material: Steel with external insulation, **as directed**.
c. Finish: None **OR** Black enamel on visible surfaces, **as directed**.
d. Slot Width: 1/2 inch (13 mm) **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm) **OR** 1-1/2 inches (38 mm), **as directed**.
e. Number of Sides: One **OR** Two, **as directed**.
f. Length: 24 inches (600 mm) **OR** 36 inches (900 mm) **OR** 48 inches (1200 mm), **as directed**.
g. Pattern: Fixed **OR** Adjustable, **as directed**.
h. Inlet: Top **OR** Side, **as directed**.
i. Inlet Size: 5 inches (125 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**.

C. Underfloor Air Distribution Diffusers
1. Round Induction Diffusers:
a. Airflow Principle: Swirl-pattern induction.
b. Material: Plastic, high impact, and resistant to cart and foot traffic.
c. Color: Gray **OR** Black, **as directed**.
d. Components:
1) Diffuser core.
2) Flow regulator.
3) Dirt and liquid catch pan.
4) Spacer flange.
5) Gasketed, underfloor compression ring.

2. Linear Floor Diffuser Plenums:
a. Material: Steel.
b. Finish: White baked acrylic.
c. Deflection: Zero **OR** 15, **as directed**, degrees.
d. Components:
1) Aluminum diffuser core.
2) Diffuser frame.
3) Plenum, 0.034-inch (0.85-mm) steel.

D. High-Capacity Diffusers
1. Drum Louver:
a. Airflow Principle: Extended distance for high airflow rates.
b. Material: Aluminum, heavy gage extruded.
c. Finish: White baked acrylic.
d. Border: 1-1/4-inch (32-mm) width with countersunk screw holes.

e. Gasket between drum and border.
f. Body: Drum shaped; adjustable vertically.
g. Blades: Individually adjustable horizontally.
h. Mounting: Surface to duct **OR** wall, **as directed**.
i. Inlet Width: 6 inches (150 mm) **OR** 10 inches (250 mm) **OR** 12 inches (300 mm) **OR** 15 inches (380 mm), **as directed**.
j. Inlet Length: 12 inches (300 mm) **OR** 24 inches (600 mm) **OR** 36 inches (900 mm) **OR** 60 inches (1500 mm), **as directed**.
k. Accessories:
1) Opposed-blade steel damper.
2) Duct-mounting collars with countersunk screw holes.

2. Modular Core Supply Grilles:
a. Throw: Extended distance for airflow rates.
b. Material: Steel.
c. Grilles per Unit: One **OR** Two **OR** Three **OR** Four, **as directed**.
d. Finish: White baked acrylic.
e. Border: 1-1/2-inch (38-mm) width with countersunk screw holes.
f. Blades:
1) Airfoil, individually adjustable horizontally.
2) Double deflection.
3) Set in modules.
g. Modules: Removable; rotatable.
h. Mounting: Surface.
i. Accessory: Opposed-blade steel damper.

E. Flexible Diffusion Outlets
1. Continuous Tubular Diffuser:
a. Material: Flame-retardant, woven polyethylene fabric **OR** Flame-retardant, coated polyester and fiberglass fabric **OR** Flame-retardant, permeable polyester and fiberglass fabric **OR** Polyethylene, **as directed**.
b. Duct Connection: Round.
c. Duct Connection Size: as directed by the Owner.
d. Diffusion Hole Size: as directed by the Owner.
e. Diffusion Hole Frequency - Number per 100 Feet (30 m): <**Insert number**>.
f. Accessories:
1) Quick-connect joint.
2) Snap hooks.
3) Cleanout zipper.
4) Condensate drain.

F. Registers And Grilles
1. Adjustable Bar Register:
a. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
c. Face Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3 inches (76 mm) **OR** 1-1/2 inches (38 mm) **OR** 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
d. Core Construction: Integral **OR** Removable, **as directed**.
e. Rear-Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
f. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
g. Mounting Frame: Filter.
h. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
i. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), **as directed**.
j. Accessories:
1) Front **OR** Rear, **as directed**,-blade gang operator.

2) Filter.

2. Adjustable Bar Grille:
   a. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
   b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
   c. Face Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3 inches (76 mm) **OR** 1-1/2 inches (38 mm) **OR** 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
   d. Core Construction: Integral **OR** Removable, **as directed**.
   e. Rear-Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced 3/4 inch (19 mm) **OR** 1/2 inch (13 mm), **as directed**, apart.
   f. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
   g. Mounting Frame: Filter.
   h. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
3. Security Register:
   a. Security Level: Maximum **OR** Medium **OR** Minimum, **as directed**, and suicide deterrent, **as directed**.
   b. Application: Ducted return **OR** Air transfer **OR** Barrier, **as directed**.
   c. Material: Steel **OR** Aluminum, **as directed**.
   d. Material Thickness: 0.19 inch (4.8 mm).
   e. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
   f. Face Arrangement:
      1) Shape: Square **OR** Rectangular **OR** Round, **as directed**.
      2) Design: Fixed bar **OR** Perforated **OR** Lattice, **as directed**.
      3) Frame: Yes **OR** No, **as directed**.
      4) Deflection: Zero **OR** 38, **as directed**, degrees.
      5) Core: None **OR** Louvered, **as directed**.
      6) 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
      7) 3/16-inch- (5-mm-) thick, perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
      8) 1-1/2-inch (38-mm) bars and mandrel tubes and rods with zero **OR** 15, **as directed**,-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
      9) 1-3/8-inch (35-mm) bars and double mandrel tubes with zero **OR** 15, **as directed**,-degree deflection in 1-3/4-inch (45-mm) angle border.
   g. Damper Operation: None **OR** Face operated **OR** Rear operated, **as directed**.
   h. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), **as directed**.
   i. Wall Sleeve: 3/16 inch (5 mm) welded to face **OR** 1/8 inch (3 mm) welded to face **OR** Mechanically fastened to border, **as directed**.
   j. Mounting: 1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame **OR** 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) retaining angle frame **OR** 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) cast-in-place frame and tamperproof machine screws, **as directed**.
4. Security Grille:
   a. Security Level: Maximum **OR** Medium **OR** Minimum, **as directed**, and suicide deterrent, **as directed**.
   b. Application: Ducted return **OR** Air transfer **OR** Barrier, **as directed**.
   c. Material: Steel **OR** Aluminum, **as directed**.
   d. Material Thickness: 0.19 inch (4.8 mm).
   e. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
   f. Face Arrangement:
      1) Shape: Square **OR** Rectangular **OR** Round, **as directed**.
      2) Design: Fixed bar **OR** Perforated **OR** Lattice, **as directed**.
      3) Frame: Yes **OR** No, **as directed**.
      4) Deflection: Zero **OR** 38, **as directed**, degrees.
      5) Core: None **OR** Louvered, **as directed**.

6) 3/16-inch- (5-mm-) thick, front lattice plate with 2-by-2-inch- (50-by-50-mm-) square holes and 1-inch (25-mm) frets, 0.135-inch (3.43-mm) wire mesh, and 1/4-inch- (6-mm-) thick backer plate.
7) 3/16-inch- (5-mm-) thick perforated faceplate with 5/16-inch- (8-mm-) diameter holes spaced 7/16 inch (11 mm) o.c., staggered at 60 degrees.
8) 1-1/2-inch (38-mm) bars and mandrel tubes and rods with zero **OR** 15, **as directed**,-degree deflection in 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) angle border.
9) 1-3/8-inch (35-mm) bars and double mandrel tubes with zero **OR** 15, **as directed**,-degree deflection in 1-3/4-inch (45-mm) angle border.

g. Wall Sleeve: 3/16 inch (5 mm) welded to face **OR** 1/8 inch (3 mm) welded to face **OR** Mechanically fastened to border, **as directed**.

h. Mounting: 1-by-1-by-3/16-inch (25-by-25-by-5-mm) retaining angle frame **OR** 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) retaining angle frame **OR** 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm) cast-in-place frame and tamperproof machine screws, **as directed**.

5. Fixed Face Register:
   a. Material: Steel **OR** Aluminum, **as directed**.
   b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
   c. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid **OR** Perforated, **as directed**, core.
   d. Core Construction: Integral **OR** Removable, **as directed**.
   e. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
   f. Mounting Frame: Filter.
   g. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
   h. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), **as directed**.
   i. Accessory: Filter.
6. Fixed Face Grille:
   a. Material: Steel **OR** Aluminum, **as directed**.
   b. Finish: Baked enamel, white **OR** Baked enamel, color selected.
   c. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid **OR** Perforated, **as directed**, core.
   d. Core Construction: Integral **OR** Removable, **as directed**.
   e. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
   f. Mounting Frame: Filter.
   g. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
   h. Accessory: Filter.
7. Linear Bar Grille:
   a. Material: Steel **OR** Aluminum, **as directed**.
   b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
   c. Face Arrangement: 1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm) grid **OR** Perforated, **as directed**, core.
   d. Distribution plenum.
      1) Internal insulation.
      2) Inlet damper.
   e. Frame: 1-1/4 inches (32 mm) **OR** 1 inch (25 mm), **as directed**, wide.
   f. Mounting Frame: Filter.
   g. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
   h. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), **as directed**.

G. Source Quality Control
   1. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

1.3 EXECUTION

A. Installation
   1. Install diffusers, registers, and grilles level and plumb.
   2. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify the Owner for a determination of final location.
   3. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

B. Adjusting
   1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 15867

Task	Specification	Specification Description
15867	15840d	Duct Accessories
15868	15840d	Duct Accessories

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SECTION 15869 - AIR TERMINAL UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for air terminal units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Bypass, single-duct air terminal units.
b. Dual-duct air terminal units.
c. Fan-powered air terminal units.
d. Induction air terminal units.
e. Shutoff, single-duct air terminal units.
f. Diffuser-type air terminal units.

C. Performance Requirements
1. Structural Performance: Hangers and supports and seismic restraints, **as directed**, shall withstand the effects of gravity and seismic, **as directed**, loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
b. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
c. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

D. Submittals
1. Product Data: For each type of product indicated.
2. LEED Submittal:
a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.
c. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
4. Delegated-Design Submittal:
a. Materials, fabrication, assembly, and spacing of hangers and supports.
b. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**, for selecting hangers and supports and seismic restraints, **as directed**.
5. Field quality-control reports.
6. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

1.2 PRODUCTS

A. Bypass, Single-Duct Air Terminal Units

1. Configuration: Diverting-damper assembly inside unit casing with control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
   a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      1) Cover liner with nonporous foil.
         OR
         Cover liner with nonporous foil and perforated metal.

      OR

      Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   b. Air Inlet: Round stub connection for duct attachment.
   c. Air Outlet: S-slip and drive connections.
   d. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
   e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Diverter Assembly: Galvanized-steel gate, with polyethylene linear bearings **OR** Aluminum blade, with nylon-fitted pivot points, **as directed**.
4. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.
5. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

   OR

   Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
   a. Access door interlocked disconnect switch.
   b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
   c. Nickel chrome 80/20 heating elements.
   d. Airflow switch for proof of airflow.
   e. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
   f. Mercury contactors.
   g. Pneumatic-electric switches and relays.
   h. Magnetic contactor for each step of control (for three-phase coils).
6. Electric Controls: Damper actuator and thermostat.
   a. Damper Actuator: 24 V, powered closed, powered open with microswitch to energize heating control circuit, **as directed**.
   b. Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.

c. Changeover Thermostat: Duct-mounted, field-adjustable, electric type reverses action of zone thermostat when air temperature reaches 70 deg F (21 deg C).

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

d. Damper Actuator: 24 V, powered closed, powered open.

e. Thermostat: Wall-mounted electronic type with the following features:

1) Temperature set-point display in Fahrenheit and Celsius.

2) Auxiliary switch to energize heating control circuit.

3) Changeover thermistor to reverse action.

B. Dual-Duct Air Terminal Units

1. Configuration: Two volume dampers inside unit casing with mixing attenuator section and control components inside a protective metal shroud with a third primary air inlet with volume damper, **as directed**.

2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.

a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

1) Cover liner with nonporous foil.

OR

Cover liner with nonporous foil and perforated metal.

OR

Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.

c. Air Outlet: S-slip and drive connections.

d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.

e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

3. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

a. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.

4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.

5. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.

a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

1) Cover liner with nonporous foil.

OR

Cover liner with nonporous foil and perforated metal.

OR

Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index

of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

6. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-) **OR** 12-inch- (300-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.

7. Pneumatic Controls: Damper operator, velocity controllers, and thermostat. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.

b. Velocity Controllers: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in cold- and hot-deck **OR** cold-, hot-, and ventilation- deck **OR** cold-deck, **as directed**, air inlets and supply air outlets.

c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.

b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.

c. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius, **as directed**.

OR

Direct Digital Controls: Single-package unitary controller and actuator specified in Division 15 Section "Hvac Instrumentation And Controls"

OR

Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

d. Damper Actuators: 24 V, powered closed, spring return open **OR** powered open, **as directed**.

e. Terminal Unit Controller: Pressure-independent, variable-air **OR** constant, **as directed**,-volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes, and having the following features:

1) Occupied and unoccupied operating mode.

2) Remote reset of airflow or temperature set points.

3) Adjusting and monitoring with portable terminal.

4) Communication with temperature-control system specified in Division 15 Section "Hvac Instrumentation And Controls".

f. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

8. Control Sequence:

a. Modulate cold-air damper to maintain room temperature.

b. Modulate warm-air damper to maintain constant airflow.

C. Parallel Fan-Powered Air Terminal Units

1. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
   a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      1) Cover liner with nonporous foil.
         OR
         Cover liner with nonporous foil and perforated metal.

      OR
      Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
   c. Air Outlet: S-slip and drive connections.
   d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
   e. Fan: Forward-curved centrifugal, located at plenum air inlet.
   f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
   a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
   b. Damper Position: Normally open **OR** closed, **as directed**.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Motor:
   a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
   c. Fan-Motor Assembly Isolation: Rubber isolators.
   d. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
   e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
6. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   a. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.
      OR
      Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.
      OR
      Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
   b. Thickness: 2 inches (50 mm) **OR** 1 inch (25 mm), **as directed**.
7. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
   a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and

having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

1) Cover liner with nonporous foil.

OR

Cover liner with nonporous foil and perforated metal.

b. Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

8. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

a. Location: Plenum air inlet.

OR

Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

a. Location: Plenum air inlet.

b. Stage(s): 1 **OR** 2 **OR** 3, **as directed**.

c. Access door interlocked disconnect switch.

d. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)

e. Nickel chrome 80/20 heating elements.

f. Airflow switch for proof of airflow.

g. Fan interlock contacts.

h. Fuses in terminal box for overcurrent protection (for coils more than 48 A).

i. Mercury contactors.

j. Pneumatic-electric switches and relays.

k. Magnetic contactor for each step of control (for three-phase coils).

9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

a. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.

b. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.

c. Disconnect Switch: Factory-mounted, fuse type.

10. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

11. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

OR

Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.

b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.

c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Occupied and unoccupied operating mode.
b. Remote reset of airflow or temperature set points.
c. Adjusting and monitoring with portable terminal.
d. Communication with temperature-control system specified in Division 15 Section "Hvac Instrumentation And Controls".

12. Control Sequence:
    a. Occupied (Primary Airflow On):
        1) Operate as throttling control for cooling.
        2) As cooling requirement decreases, control valve throttles toward minimum airflow.
        3) As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps, **as directed**.
    b. Unoccupied (Primary Airflow Off):
        1) When pressure at primary inlet is zero or less, fan is de-energized.
        2) As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps, **as directed**.

D. Series Fan-Powered Air Terminal Units

1. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling and within a raised access floor, **as directed**.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
    a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
        1) Cover liner with nonporous foil.
        OR
        Cover liner with nonporous foil and perforated metal.

        OR
        Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
    c. Air Outlet: S-slip and drive connections.
    d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
    e. Fan: Forward-curved centrifugal.
    f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
    a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
    b. Damper Position: Normally open **OR** closed, **as directed**.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Motor:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
c. Fan-Motor Assembly Isolation: Rubber isolators.
d. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.

6. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
   a. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.
      OR
      Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.
      OR
      Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
   b. Thickness: 2 inches (50 mm) **OR** 1 inch (25 mm), **as directed**.
7. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
   a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      1) Cover liner with nonporous foil.
         OR
         Cover liner with nonporous foil and perforated metal.

      OR
      Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
8. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
   OR
   Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
   a. Stage(s): 1 **OR** 2 **OR** 3, **as directed**.
   b. Access door interlocked disconnect switch.
   c. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
   d. Nickel chrome 80/20 heating elements.
   e. Airflow switch for proof of airflow.
   f. Fan interlock contacts.
   g. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
   h. Mercury contactors.
   i. Pneumatic-electric switches and relays.
   j. Magnetic contactor for each step of control (for three-phase coils).
9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

a. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
b. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
c. Disconnect Switch: Factory-mounted, fuse type.

10. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
11. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.
OR
Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:
a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.
OR
Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:
a. Occupied and unoccupied operating mode.
b. Remote reset of airflow or temperature set points.
c. Adjusting and monitoring with portable terminal.
d. Communication with temperature-control system specified in Division 15 Section "Hvac Instrumentation And Controls".
12. Control Sequence:
a. Occupied (Primary Airflow On):
1) When pressure at inlet is at least 1.2-inch wg (300 Pa).
2) As cooling requirement decreases, control valve throttles toward minimum airflow.
b. Unoccupied (Primary Airflow Off):
1) When pressure at primary inlet is zero or less, fan is de-energized.

E. Induction Air Terminal Units
1. Configuration: Volume-damper assembly inside unit casing with mechanical induction damper mounted on casing and control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
1) Cover liner with nonporous foil.
OR
Cover liner with nonporous foil and perforated metal.
OR
Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

b. Air Inlet: Round stub connection for duct attachment.
c. Air Outlet: S-slip and drive connections, size matching inlet size, **as directed**.
d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
e. Fan: Forward-curved centrifugal.
f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

3. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
   b. Damper Position: Normally open **OR** closed, **as directed**.
4. Induction Damper: Galvanized-steel, multiblade assembly with self-lubricating bearings.
5. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

   OR

   Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
   a. Access door interlocked disconnect switch.
   b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
   c. Nickel chrome 80/20 heating elements.
   d. Airflow switch for proof of airflow.
   e. Fan interlock contacts.
   f. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
   g. Mercury contactors.
   h. Pneumatic-electric switches and relays.
   i. Magnetic contactor for each step of control (for three-phase coils).
6. Pneumatic Controls: Damper operator, velocity controller, and induction damper operator. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:
   a. Damper Operator: Pneumatic, 0- to 13-psig (0- to 90-kPa) spring range.
   b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
   c. Induction Damper Operator: Pneumatic, spring range matching reset range of controller.
   d. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

   OR

   Electronic Controls: Pneumatic damper operators, electronic controller integral airflow transducer, and electronic thermostat. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:
   a. Damper Actuator: Pneumatic, 0- to 13-psig (0- to 90-kPa) spring range.
   b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
   c. Induction Damper Operator: Pneumatic, spring range matching reset range of controller.
   d. Thermostat: Wall-mounted electronic type with the following features:
      1) Proportional, plus integral control of room temperature.
      2) Time-proportional reheat-coil control.
      3) Temperature set-point display in Fahrenheit and Celsius.

F. Shutoff, Single-Duct Air Terminal Units
1. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
   a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      1) Cover liner with nonporous foil.
         OR
         Cover liner with nonporous foil and perforated metal.

      OR
      Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   b. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
   c. Air Outlet: S-slip and drive connections, size matching inlet size, **as directed**.
   d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
   e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F (minus 18 to plus 60 deg C), shall be impervious to moisture and fungus, shall be suitable for 10-inch wg (2500-Pa) static pressure, and shall be factory tested for leaks.
4. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at 3-inch wg (750-Pa) **OR** 6-inch wg (1500-Pa), **as directed**, inlet static pressure.
   b. Damper Position: Normally open **OR** closed, **as directed**.
5. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
   a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      1) Cover liner with nonporous foil.
         OR
         Cover liner with nonporous foil and perforated metal.

      OR
      Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
   b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
6. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.
7. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
   OR

Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

a. Access door interlocked disconnect switch.
b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
c. Nickel chrome 80/20 heating elements.
d. Airflow switch for proof of airflow.
e. Fan interlock contacts.
f. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
g. Mercury contactors.
h. Pneumatic-electric switches and relays.
i. Magnetic contactor for each step of control (for three-phase coils).

8. Electric Controls: Damper actuator and thermostat.
   a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
   b. Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.

OR

Pneumatic Controls: Damper operator and velocity controller. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

OR

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
c. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.

OR

Direct Digital Controls: Single-package unitary controller and actuator specified in Division 15 Section "Hvac Instrumentation And Controls".

OR

Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:

a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
b. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
   1) Occupied and unoccupied operating mode.

2) Remote reset of airflow or temperature set points.
3) Adjusting and monitoring with portable terminal.
4) Communication with temperature-control system specified in Division 15 Section "Hvac Instrumentation And Controls".

c. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.

9. Control Sequence:
   a. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.
   b. System-powered, wall-mounted thermostat.

G. Diffuser-Type Air Terminal Units
1. Configuration: Volume-damper, diffuser, controller assembly and electric heater, **as directed**, and wall-mounted thermostat with master-slave capability, **as directed**.
2. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
   a. Damper Position: Normally open **OR** closed, **as directed**.
3. Diffuser: Galvanized steel with white baked-enamel finish.
4. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 15 Section "Hvac Instrumentation And Controls" and shall have the following features:
   a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
   b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
   c. Thermostat: Wall-mounted electronic type with the following features:
      1) Proportional, plus integral control of room temperature.
      2) Temperature set-point display in Fahrenheit and Celsius.
5. Integral thermally powered actuators control diffusion dampers based on duct and room temperature.

H. Hangers And Supports
1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
3. Steel Cables: Galvanized steel complying with ASTM A 603 **OR** Stainless steel complying with ASTM A 492, **as directed**.
4. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
5. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
6. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

I. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
   a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to

braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

3. Restraint Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**,-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

J. Source Quality Control

1. Factory Tests, as directed: Test factory-assembled air terminal units according to ARI 880.
   a. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, **as directed**, and ARI certification seal.

1.3 EXECUTION

A. Installation

1. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
2. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
3. Install wall-mounted thermostats.

B. Hanger And Support Installation

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   a. Where practical, install concrete inserts before placing concrete.
   b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
   c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
   d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
   e. Do not use powder-actuated concrete fasteners for seismic restraints.
3. Hangers Exposed to View: Threaded rod and angle or channel supports.
4. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

C. Seismic-Restraint-Device Installation

1. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
2. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install cable restraints on air terminal units that are suspended with vibration isolators.
5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

7. Drilling for and Setting Anchors:

8. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
9. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
10. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
11. Set anchors to manufacturer's recommended torque, using a torque wrench.
12. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

D. Connections
1. Install piping adjacent to air terminal unit to allow service and maintenance.
2. Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping", connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
3. Connect ducts to air terminal units according to Division 15 Section(s) "Metal Ducts" OR "Nonmetal Ducts", **as directed**.
4. Make connections to air terminal units with flexible connectors complying with requirements in Division 15 Section "Duct Accessories".

E. Identification
1. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 15 Section "Identification For Hvac Piping And Equipment" for equipment labels and warning signs and labels.

F. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
   b. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
   c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Air terminal unit will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

G. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
   c. Verify that controls and control enclosure are accessible.
   d. Verify that control connections are complete.
   e. Verify that nameplate and identification tag are visible.
   f. Verify that controls respond to inputs as specified.

H. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 15869

Task	Specification	Specification Description
15869	15867	Diffusers, Registers, And Grilles
15871	15867	Diffusers, Registers, And Grilles
15872	15867	Diffusers, Registers, And Grilles

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SECTION 15880 - AIR FILTERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for particulate air infiltration. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Metal panel filters.
b. Flat panel filters.
c. Pleated panel filters.
d. Ring panel filters.
e. Nonsupported bag filters.
f. Supported bag filters.
g. Rigid cell box filters.
h. V-bank cell filters.
i. Self-supported pocket filters.
j. Automatic roll filters.
k. Bulk media.
l. Front- and rear-access filter frames.
m. Side-service housings.
n. Filter gages.

C. Submittals
1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittals:
a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
c. Wiring Diagrams: For power, signal, and control wiring.
4. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
a. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."

b. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

3. Comply with NFPA 90A and NFPA 90B.

E. Coordination

1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.2 PRODUCTS

A. Metal Panel Filters

1. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.
2. Media: Four **OR** Six, **as directed**, alternate layers of galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, flat and herringbone-crimp screen.
   a. Nonoiled for grease removal application.
   b. Adhesive coating.
      1) Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Filter-Media Frame: Galvanized steel **OR** Hot-dip galvanized steel **OR** Aluminum **OR** Stainless steel, **as directed**, hinged, and with pull and retaining handles fastened to the media.
   a. Drain holes.

B. Flat Panel Filters

1. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Interlaced glass or synthetic fibers **OR** Cotton and synthetic fibers, **as directed**, coated with nonflammable adhesive.
   a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Media shall be coated with an antimicrobial agent.
   c. Metal Retainer: Upstream side and downstream side.
4. Filter-Media Frame: Cardboard with perforated metal retainer **OR** Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles, **as directed**, sealed or bonded to the media.
5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

C. Pleated Panel Filters

1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Interlaced glass or synthetic fibers **OR** Cotton and synthetic fibers, **as directed**, coated with nonflammable adhesive.
   a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Media shall be coated with an antimicrobial agent.
   c. Separators shall be bonded to the media to maintain pleat configuration.
   d. Welded wire grid shall be on downstream side to maintain pleat.
   e. Media shall be bonded to frame to prevent air bypass.
   f. Support members on upstream and downstream sides to maintain pleat spacing.
4. Filter-Media Frame: Cardboard frame with perforated metal retainer **OR** Galvanized steel **OR** Aluminized steel, **as directed**, with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles, **as directed**, sealed or bonded to the media.

5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

D. Ring Panel Filters
1. Description: Internally supported, flat panel filters for installation in a filter track.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Two **OR** Three **OR** Four, **as directed**,-ply polyester with sealed edges.
   a. Panel Construction: Single with one edge unsealed for support removal, **as directed**, **OR** Linked, **as directed**.
   b. Media shall be coated with an antimicrobial agent.
4. Internal Support: 9-gage steel wire frame.

E. Nonsupported Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Glass-fiber **OR** Synthetic, **as directed**, material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   a. Media shall be coated with an antimicrobial agent.
4. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Supported Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, self-supported filters with holding frames in steel, basket-type retainers.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   a. Media shall be coated with an antimicrobial agent.
4. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

G. Rigid Cell Box Filters
1. Description: Factory-fabricated, adhesive-coated, **as directed**, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Media shall be coated with an antimicrobial agent.
4. Filter-Media Frames: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

H. V-Bank Cell Filters
1. Description: Factory-fabricated, adhesive-coated, **as directed**, disposable, packaged air filters with media angled to airflow, and with holding frames.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   b. Media shall be coated with an antimicrobial agent.
4. Filter-Media Frames: Galvanized steel **OR** Hard polyurethane foam, **as directed**.

5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

I. Self-Supported Pocket Filters
1. Description: Factory-fabricated, panel-type, disposable air filters with contoured media for extended surface.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
   a. Media shall be coated with an antimicrobial agent.
4. Configuration: Single-pocket cube **OR** Multipocket, **as directed**.
5. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
6. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

J. Automatic Roll Filters
1. Description: Factory-fabricated, automatic, motor-driven, roll-type filters with holding casing.
2. Arrangement: Horizontal **OR** Vertical, **as directed**.
3. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
4. Media: Compressed and rolled, fibrous-glass material; viscous coated.
   a. Media shall be coated with an antimicrobial agent.
5. Holding Frame: Galvanized steel with enclosed, clean media roll arranged to allow upstream replacement of filter media.
   a. Auxiliary Frame: Locate on downstream side of unit with downstream **OR** side, **as directed**, access.
   b. Final Filter: Extended-surface, retained **OR** nonsupported, **as directed**, media.
6. Control and Drive: Electric, gear-reducer, motor-driven, feed-control mechanism equipped with manual media advance and runout switches for stopping media movement of filter bank and operating remote warning signal lights.
   a. Manual Control: Manual switch to advance media, and wired to override automatic controls.
   b. Automatic Control: Prewired control package to advance media when filter resistance exceeds preselected high limit **OR** after preselected operating time, **as directed**.

K. Bulk Media
1. Description: Air-filter media, factory custom cut or rolled.
2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
3. Media: Spun glass **OR** Synthetic **OR** Polyester, **as directed**, in a roll **OR** cut into pads, **as directed**.

L. Front- And Rear-Access Filter Frames
1. Framing System: Galvanized-steel **OR** Aluminum, **as directed**, framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
2. Prefilters: Incorporate a separate track with spring clips, **as directed**, removable from front or back, **as directed**.
3. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

M. Side-Service Housings
1. Description: Factory-assembled, side-service housings, constructed of galvanized steel **OR** aluminum, **as directed**, with flanges to connect to duct or casing system.
2. Prefilters: Integral tracks to accommodate 2-inch- (50-mm-) deep, disposable or washable, **as directed**, filters.

3. Access Doors: Hinged, with continuous **OR** Continuous, **as directed**, gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.
4. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

N. Filter Gages
1. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
   a. Diameter: 4-1/2 inches (115 mm) **OR** 2 inches (50 mm), **as directed**.
   b. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
   c. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
   d. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
   e. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
   f. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).
2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full scale range.
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

1.3 EXECUTION

A. Installation
1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Install filter gage for each filter bank.
4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
5. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
6. Coordinate filter installations with duct and air-handling-unit installations.

B. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Operate automatic roll filters to demonstrate compliance with requirements.
   b. Test for leakage of unfiltered air while system is operating.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning
1. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 15880

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Task	Specification	Specification Description
15883	15880	Air Filters

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SECTION 15910 - HVAC INSTRUMENTATION AND CONTROLS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for HVAC instrumentation and controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

C. Definitions
1. DDC: Direct digital control.
2. I/O: Input/output.
3. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
4. MS/TP: Master slave/token passing.
5. PC: Personal computer.
6. PID: Proportional plus integral plus derivative.
7. RTD: Resistance temperature detector.

D. System Performance
1. Comply with the following performance requirements:
   a. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
   b. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
   c. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
   d. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
   e. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
   f. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
   g. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
   h. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
      1) Water Temperature: Plus or minus 1 deg F (0.5 deg C).
      2) Water Flow: Plus or minus 5 percent of full scale.
      3) Water Pressure: Plus or minus 2 percent of full scale.
      4) Space Temperature: Plus or minus 1 deg F (0.5 deg C).
      5) Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
      6) Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
      7) Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
      8) Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
      9) Relative Humidity: Plus or minus 5 percent.
      10) Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
      11) Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
      12) Airflow (Terminal): Plus or minus 10 percent of full scale.

13) Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
14) Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
15) Carbon Monoxide: Plus or minus 5 percent of reading.
16) Carbon Dioxide: Plus or minus 50 ppm.
17) Electrical: Plus or minus 5 percent of reading.

E. Submittals

1. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
   a. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
   b. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
   c. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   a. Bill of materials of equipment indicating quantity, manufacturer, and model number.
   b. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
   c. Wiring Diagrams: Power, signal, and control wiring.
   d. Details of control panel faces, including controls, instruments, and labeling.
   e. Written description of sequence of operation.
   f. Schedule of dampers including size, leakage, and flow characteristics.
   g. Schedule of valves including flow characteristics.
   h. DDC System Hardware:
      1) Wiring diagrams for control units with termination numbers.
      2) Schematic diagrams and floor plans for field sensors and control hardware.
      3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
   i. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
   j. Controlled Systems:
      1) Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
      2) Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
      3) Written description of sequence of operation including schematic diagram.
      4) Points list.
3. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
4. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.
5. Software and Firmware Operational Documentation: Include the following:
   a. Software operating and upgrade manuals.
   b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
   c. Device address list.
   d. Printout of software application and graphic screens.
   e. Software license required by and installed for DDC workstations and control systems.

6. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
7. Field quality-control test reports.
8. Operation and maintenance data.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with ASHRAE 135 for DDC system components.

G. Delivery, Storage, And Handling
1. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
2. System Software: Update to latest version of software at Project completion.

1.2 PRODUCTS

A. Control System
1. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
2. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.
3. Control system shall include the following:
   a. Building intrusion detection system specified in Division 13 Section "Intrusion Detection".
   b. Building clock control system specified in Division 13 Section "Clock And Program Control".
   c. Building lighting control system specified in Division 13 Section "Lighting Controls".
   d. Fire alarm system specified in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed**.

B. DDC Equipment
1. Operator Workstation: One **OR** Two, **as directed**, PC-based microcomputer(s) with minimum configuration as follows:
   a. Motherboard: With 8 integrated USB 2.0 ports, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
   b. Processor: Intel Pentium 4, <**Insert clock speed**> MHz.
   c. Random-Access Memory: 512 MB.
   d. Graphics: Video adapter, minimum 1280 x 1024 **OR** 1600 x 1200, **as directed**, pixels, 64-MB video memory, with TV out.
   e. Monitor: 17 inches (430 mm) **OR** 19 inches (480 mm), **as directed**, LCD color.
   f. Keyboard: QWERTY, 105 keys in ergonomic shape.
   g. Floppy-Disk Drive: 1.44 MB.
   h. Hard-Disk Drive: 80 GB.
   i. CD-ROM Read/Write Drive: 48x24x48.
   j. Mouse: Three button, optical.
   k. Uninterruptible Power Supply: 2 kVa.
   l. Operating System: Microsoft Windows XP Professional with high-speed Internet access.
      1) ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

2) LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

m. Printer: Black-and-white, laser-jet type as follows:
1) Print Head: 1200 x 1200 dpi resolution.
2) Paper Handling: Minimum of 250 sheet trays.
3) Print Speed: Minimum of 120 characters per second.

n. Printer: Color, ink-jet type as follows:
1) Print Head: 4800 x 1200 dpi optimized color resolution.
2) Paper Handling: Minimum of 100 sheets.
3) Print Speed: Minimum of 17 ppm in black and 12 ppm in color.

o. Application Software:
1) I/O capability from operator station.
2) System security for each operator via software password and access levels.
3) Automatic system diagnostics; monitor system and report failures.
4) Database creation and support.
5) Automatic and manual database save and restore.
6) Dynamic color graphic displays with up to 10 screen displays at once.
7) Custom graphics generation and graphics library of HVAC equipment and symbols.
8) Alarm processing, messages, and reactions.
9) Trend logs retrievable in spreadsheets and database programs.
10) Alarm and event processing.
11) Object and property status and control.
12) Automatic restart of field equipment on restoration of power.
13) Data collection, reports, and logs. Include standard reports for the following:
a) Current values of all objects.
b) Current alarm summary.
c) Disabled objects.
d) Alarm lockout objects.
e) Logs.
14) Custom report development.
15) Utility and weather reports.
16) Workstation application editors for controllers and schedules.
17) Maintenance management.

p. Custom Application Software:
1) English language oriented.
2) Full-screen character editor/programming environment.
3) Allow development of independently executing program modules with debugging/simulation capability.
4) Support conditional statements.
5) Support floating-point arithmetic with mathematic functions.
6) Contains predefined time variables.

2. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:

a. System: With one integrated USB 2.0 port, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
b. Processor: Intel Pentium 4, <**Insert clock speed**> MHz.
c. Random-Access Memory: 128 MB.
d. Graphics: Video adapter, minimum 800 x 600 **OR** 1024 x 768, **as directed**, pixels, 64-MB video memory.
e. Monitor: 17 inches (430 mm) **OR** 19 inches (480 mm), **as directed**, LCD color.
f. Keyboard: QWERTY 105 keys in ergonomic shape.
g. Floppy-Disk Drive: 1.44 MB.
h. Hard-Disk Drive: 800 MB.
i. CD-ROM Read/Write Drive: 48x24x48.
j. Pointing Device: Touch pad or other internal device.

3. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
   a. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
   b. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      1) Global communications.
      2) Discrete/digital, analog, and pulse I/O.
      3) Monitoring, controlling, or addressing data points.
      4) Software applications, scheduling, and alarm processing.
      5) Testing and developing control algorithms without disrupting field hardware and controlled environment.
   c. Standard Application Programs:
      1) Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
      2) HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
      3) Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
      4) Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
      5) Remote communications.
      6) Maintenance management.
      7) Units of Measure: Inch-pound and SI (metric).
   d. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
   e. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
   f. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
4. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
   a. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
   b. Stand-alone mode control functions operate regardless of network status. Functions include the following:
      1) Global communications.
      2) Discrete/digital, analog, and pulse I/O.
      3) Monitoring, controlling, or addressing data points.
   c. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
   d. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
   e. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
5. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
   a. Binary Inputs: Allow monitoring of on-off signals without external power.
   b. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
   c. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

d. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights, **as directed**.
e. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer, **as directed**.
f. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
g. Universal I/Os: Provide software selectable binary or analog outputs.

6. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
   a. Output ripple of 5.0 mV maximum peak to peak.
   b. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
   c. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
7. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
   a. Minimum dielectric strength of 1000 V.
   b. Maximum response time of 10 nanoseconds.
   c. Minimum transverse-mode noise attenuation of 65 dB.
   d. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

C. Unitary Controllers
1. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
   a. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
   b. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock, **as directed**. Perform automatic system diagnostics; monitor system and report failures.
   c. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
   d. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
   e. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).
   f. Enclosure: Waterproof rated for operation at 40 to 150 deg F (5 to 65 deg C).

D. Alarm Panels
1. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels, **as directed**.
2. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
   a. Alarm Condition: Indicating light flashes and horn sounds.
   b. Acknowledge Switch: Horn is silent and indicating light is steady.
   c. Second Alarm: Horn sounds and indicating light is steady.
   d. Alarm Condition Cleared: System is reset and indicating light is extinguished.
   e. Contacts in alarm panel allow remote monitoring by independent alarm company.

E. Analog Controllers
1. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
2. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.
3. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
   a. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.
4. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.
5. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
   a. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig (21 to 90 kPa).
   b. Proportional band shall extend from 2 to 20 percent for 5 psig (35 kPa).
   c. Authority shall be 20 to 200 percent.
   d. Air-supply pressure of 18 psig (124 kPa), input signal of 3 to 15 psig (21 to 103 kPa), and output signal of zero to supply pressure.
   e. Gages: 1-1/2 inches (38 mm) **OR** 2-1/2 inches (64 mm) **OR** 3-1/2 inches (89 mm), **as directed**, in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

F. Time Clocks
1. Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
2. Solid-state, programmable time control with 4 **OR** 8, **as directed**, separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

G. Electronic Sensors
1. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. Thermistor Temperature Sensors and Transmitters:
   a. Accuracy: Plus or minus 0.5 deg F (0.3 deg C) **OR** 0.36 deg F (0.2 deg C), **as directed**, at calibration point.
   b. Wire: Twisted, shielded-pair cable.
   c. Insertion Elements in Ducts: Single point, 8 inches (200 mm) **OR** 18 inches (460 mm), **as directed**, long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
   d. Averaging Elements in Ducts: 36 inches (915 mm) long, flexible **OR** 72 inches (1830 mm) long, flexible **OR** 18 inches (460 mm) long, rigid, **as directed**; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).
   e. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
   f. Room Sensor Cover Construction: Manufacturer's standard locking covers.
      1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
      2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.

3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
4) Color: As selected from manufacturer's full range.
5) Orientation: Vertical **OR** Horizontal, **as directed**.

g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

3. RTDs and Transmitters:
a. Accuracy: Plus or minus 0.2 percent at calibration point.
b. Wire: Twisted, shielded-pair cable.
c. Insertion Elements in Ducts: Single point, 8 inches (200 mm) **OR** 18 inches (460 mm), **as directed**, long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
d. Averaging Elements in Ducts: 18 inches (460 mm) long, rigid **OR** 24 inches (610 mm) long, rigid **OR** 48 inches (1200 mm) long, rigid **OR** 24 feet (7.3 m) long, flexible, **as directed**; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (0.84 sq. m); length as required.
e. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
f. Room Sensor Cover Construction: Manufacturer's standard locking covers.
1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed\, **as directed**.
3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
4) Color: As selected from manufacturer's full range.
5) Orientation: Vertical **OR** Horizontal, **as directed**.

g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

4. Humidity Sensors: Bulk polymer sensor element.
a. Accuracy: 5 **OR** 2, **as directed**, percent full range with linear output.
b. Room Sensor Range: 20 to 80 percent relative humidity.
c. Room Sensor Cover Construction: Manufacturer's standard locking covers.
1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
4) Color: As selected from manufacturer's full range.
5) Orientation: Vertical **OR** Horizontal, **as directed**.

d. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
e. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of 32 to 120 deg F (0 to 50 deg C) **OR** minus 22 to plus 185 deg F (minus 30 to plus 85 deg C) **OR** minus 40 to plus 170 deg F (minus 40 to plus 76 deg C), **as directed**.
f. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

5. Pressure Transmitters/Transducers:
a. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
1) Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
2) Output: 4 to 20 mA.
3) Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
4) Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).

b. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
c. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
d. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
e. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
   a. Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
   b. Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
   c. Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
   d. Color: As selected from manufacturer's full range.
   e. Orientation: Vertical **OR** Horizontal, **as directed**.
7. Room sensor accessories include the following:
   a. Insulating Bases: For sensors located on exterior walls.
   b. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base **OR** Metal wire, tamperproof **OR** Locking, solid metal, ventilated, **as directed**.
   c. Adjusting Key: As required for calibration and cover screws.

H. Pneumatic Sensors
1. Pneumatic Transmitters: Vibration and corrosion resistant.
   a. Space-Temperature Sensors: Linear-output type, 50 to 100 deg F (10 to 38 deg C) range, with blank locking covers matching room thermostats.
   b. Room Return-Air Temperature Sensors: Linear-output type with bimetal sensing element and corrosion-proof construction, 50 to 100 deg F (10 to 38 deg C) range, designed to be mounted in light troffers.
   c. Duct-Mounted or Immersion-Type Temperature Sensors: Range as required for 3- to 15-psig (21- to 103-kPa) output signal.
   d. Temperature Transmitters: Rigid-stem type with bimetal sensing elements unless averaging is required, 3- to 15-psig (21- to 103-kPa) output signal.
      1) Averaging-Element Sensors: Single- or multiple-unit capillary elements.
      2) Tamperproof Sensors: Corrosion-resistant construction, suitable for mounting on vibrating surface with exposed capillary protected with temperature-compensated armor or protective tubing.
      3) Pipe-Mounted Temperature-Sensing Elements: Rod-and-tube type; with separable wells filled with heat-conductive compound.
      4) Outdoors: Provide bulb shield with mounting bracket.
   e. Space and Duct Humidity Transmitters: One pipe, directly proportional, with minimum sensing span of 20 to 80 percent relative humidity for 3- to 15-psig (21- to 103-kPa) output signal, corrosion resistant and temperature compensated, and with factory-calibrated adjustment.
      1) Space Mounting: With covers to match thermostats.
   f. Differential-Pressure Transmitters: One pipe, direct acting for gas, liquid, or steam service; pressure sensor and transmitter of linear-output type; with range of 0 to 50 psig (0 to 344 kPa), and 3- to 15-psig (21- to 103-kPa) output signal.
   g. Differential-Air-Pressure Transmitters: One pipe, direct acting, double bell; unidirectional with suitable range for expected input; and temperature compensated.
      1) Accuracy: 5 percent of full range and 2 percent of full scale at midrange.
      2) Output Signal: 3 to 15 psig (21 to 103 kPa).
2. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to 0 to 20 psig (0 to 140 kPa).
3. Pneumatic Valve/Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

I. Status Sensors
   1. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).
   2. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
   3. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
   4. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
   5. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
   6. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
   7. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
   8. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

J. Gas Detection Equipment
   1. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F (0 to 40 deg C); with 2 factory-calibrated alarm levels at 50 and 100 **OR** 35 and 200, **as directed**, ppm.
   2. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output;, for wall mounting.
   3. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F (0 to 593 deg C) and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.
   4. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

K. Flow Measuring Stations
   1. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.
      a. Casing: Galvanized-steel frame.
      b. Flow Straightener: Aluminum honeycomb, 3/4-inch (20-mm) parallel cell, 3 inches (75 mm) deep.
      c. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

L. Thermostats
   1. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
      a. Label switches "FAN ON-OFF" **OR** "FAN HIGH-LOW-OFF" **OR** "FAN HIGH-MED-LOW-OFF", **as directed**.
      b. Mount on single electric switch box.
   2. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
      a. Automatic switching from heating to cooling.
      b. Preferential rate control to minimize overshoot and deviation from set point.
      c. Set up for four separate temperatures per day.
      d. Instant override of set point for continuous or timed period from 1 hour to 31 days.
      e. Short-cycle protection.

f. Programming based on weekday, Saturday, and Sunday **OR** every day of week, **as directed**.
g. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
h. Battery replacement without program loss.
i. Thermostat display features include the following:
1) Time of day.
2) Actual room temperature.
3) Programmed temperature.
4) Programmed time.
5) Duration of timed override.
6) Day of week.
7) System mode indications include "heating," "off," "fan auto," and "fan on."

3. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
4. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
a. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
b. Selector Switch: Integral, manual on-off-auto.
5. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
a. Bulbs in water lines with separate wells of same material as bulb.
b. Bulbs in air ducts with flanges and shields.
c. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
d. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
e. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
f. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
6. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature, and the following:
a. Reset: Manual.
OR
Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.
7. Pneumatic Room Thermostats: One **OR** Two **OR** Three, **as directed**, pipe(s), fully proportional with adjustable throttling range and tamperproof locking settings, direct or reverse acting as required. Factory calibrated at 2.5 psig/deg F (17.2 kPa/deg C).
a. Factory Calibration: 2.5 psig/deg F (17.2 kPa/deg C).
b. Range: 45 to 85 deg F (7 to 30 deg C).
c. Sensitivity Adjustment Range: 1 to 4 psig/deg F (7 to 27.6 kPa/deg C).
d. Dual-Temperature Thermostats: Automatic changeover from normal setting to lower setting for unoccupied cycles, with manual-reset lever to permit return to normal temperatures during unoccupied cycles, with automatic reset to normal during next cycle of operation.
e. Limits: Field adjustable, to limit setting cooling set point below 75 deg F (24 deg C), and heating set point above 75 deg F (24 deg C).
f. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.

2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
4) Color: As selected from manufacturer's full range.
5) Orientation: Vertical **OR** Horizontal, **as directed**.

g. Room thermostat accessories include the following:
1) Insulating Bases: For thermostats located on exterior walls.
2) Thermostat Guards: Locking; heavy-duty, transparent plastic; mounted on separate base **OR** Metal wire, tamperproof **OR** Locking, solid metal, ventilated, **as directed**.
3) Adjusting Key: As required for calibration and cover screws.
4) Aspirating Boxes: For flush-mounted aspirating thermostats.
5) Set-Point Adjustment: 1/2-inch- (13-mm-) diameter, adjustment knob.

8. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
9. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
10. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-, **as directed**, reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.
a. Bulb Length: Minimum 20 feet (6 m).
b. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.
11. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-, **as directed**, reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.
a. Bulb Length: Minimum 20 feet (6 m).
b. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.
12. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig (172 kPa), and cast housing with position indicator and adjusting knob.

M. Humidistats
1. Pneumatic Room Humidistats: Wall-mounting, proportioning type with adjustable throttling range, 20 to 90 **OR** 55 to 95 **OR** 25 to 65, **as directed**, percent operating range, and cover matching room thermostat cover.
2. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.
3. Pneumatic Duct-Mounting Humidistats: Proportioning type with adjustable throttling range, 20 to 90 **OR** 55 to 95 **OR** 25 to 65, **as directed**, percent operating range, in galvanized-steel duct box.

N. Actuators
1. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
a. Comply with requirements in Division 15 Section "Common Motor Requirements For Hvac Equipment".
b. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
c. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
d. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
e. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).

f. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

2. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
   a. Valves: Size for torque required for valve close off at maximum pump differential pressure.
   b. Dampers: Size for running torque calculated as follows:
      1) Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
      2) Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
      3) Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
      4) Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
      5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
      6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
   c. Coupling: V-bolt and V-shaped, toothed cradle.
   d. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
   e. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
   f. Power Requirements (Two-Position Spring Return): 24 **OR** 120 **OR** 230, **as directed**,-V ac.
   g. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
   h. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
   i. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) **OR** 40 to 104 deg F (5 to 40 deg C), **as directed**.
   j. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
   k. Run Time: 12 seconds open, 5 seconds closed **OR** 30 seconds **OR** 60 seconds **OR** 120 seconds, **as directed**.
3. Pneumatic Valve Operators: Rolling-diaphragm, spring-loaded, piston type with spring range as required and start-point adjustment and positioning relay, **as directed**. Operator shall maintain full shutoff at maximum pump differential pressure.
4. Pneumatic Damper Operators: Rolling-diaphragm, piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.
   a. Pilot Positioners: With the following characteristics:
      1) Start Point: Adjustable from 2 to 12 psig (14 to 83 kPa).
      2) Operating Span: Adjustable from 5 to 13 psig (35 to 90 kPa).
      3) Linearity: Plus or minus 10 percent of output signal span.
      4) Hysteresis: 3 percent of span.
      5) Response: 0.25-psig (1723-Pa) input change.
      6) Maximum Pilot Signal Pressure: 20 psig (140 kPa).
      7) Maximum Control Air-Supply Pressure: 60 psig (410 kPa).
   b. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F (10 to 60 deg C) unless located in return-air plenums, **as directed**.
   c. Inlet-Vane Operators: High pressure, with pilot positioners.

O. Control Valves
1. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
2. Hydronic system globe valves shall have the following characteristics:

a. NPS 2 (DN 50) and Smaller: Class 125 **OR** 250, **as directed**, bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
b. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
c. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
   1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
   2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
d. Sizing: 3-psig (21-kPa) **OR** 5-psig (35-kPa), **as directed**, maximum pressure drop at design flow rate or the following:
   1) Two Position: Line size.
   2) Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
   3) Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
e. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
f. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

3. Steam system globe valves shall have the following characteristics:
   a. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
   b. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
   c. Internal Construction: Replaceable plugs and stainless-steel seats.
      1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
      2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
   d. Sizing: For pressure drop based on the following services:
      1) Two Position: 20 percent of inlet pressure.
      2) Modulating 15-psig (103-kPa) Steam: 80 percent of inlet steam pressure.
      3) Modulating 16- to 50-psig (110- to 350-kPa) Steam: 50 percent of inlet steam pressure.
      4) Modulating More Than 50-psig (350-kPa) Steam: As indicated.
   e. Flow Characteristics: Modified linear characteristics.
   f. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.
4. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1034-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
   a. Body Style: Wafer **OR** Lug **OR** Grooved, **as directed**.
   b. Disc Type: Nickel-plated ductile iron **OR** Aluminum bronze **OR** Elastomer-coated ductile iron **OR** Epoxy-coated ductile iron, **as directed**.
   c. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
5. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
   a. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
   b. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.

c. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

6. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
   a. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
   b. Thermostatic Operator: Wax **OR** Liquid, **as directed**,-filled integral **OR** remote, **as directed**, sensor with integral **OR** remote, **as directed**, adjustable dial.

P. Dampers
1. Dampers: AMCA-rated, parallel **OR** opposed, **as directed**,-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
   a. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze **OR** nylon, **as directed**, blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
   b. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
   c. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
      OR
      Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

Q. Air Supply
1. Control and Instrumentation Tubing: Copper tubing complying with ASTM B 88, Type K (ASTM B 88M, Type A) or ASTM B 280 Type ACR.
   a. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
   b. Joining Method: Soldered or brazed.
   OR
   Control and Instrumentation Tubing: ASTM D 2737 Type FR plenum-rated polyethylene, flame-retardant, nonmetallic tubing rated for 30 psig (207 kPa) and ambient temperature range of 10 to 150 deg F (minus 13 to plus 65 deg C) with flame-retardant harness for multiple tubing.
   c. Fittings: Compression or push-on polyethylene fittings.
2. Tank: ASME storage tank with drain test cock, automatic moisture removal trap, tank relief valve, and rubber-cork vibration isolation mounting pads.
3. Duplex Air Compressor: Capacity to supply compressed air to temperature-control system.
   a. Pressure control with adjustable electric contacts, set to start and stop both compressors at different pressures.
   b. Electrical alternation set with motor starters and disconnect to operate compressors alternately or on time schedule.
4. Simplex Air Compressor: Tank-mounting compressor with capacity to supply compressed air to temperature-control system, with starter and disconnect.
   a. Pressure control with adjustable electric contacts, set to start and stop compressor.
5. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
6. Size compressor and tank to operate compressor not more than 20 **OR** 30, **as directed**, minutes during a 60-minute period.
7. Compressor Accessories: Low-resistance intake-air filter, and belt guards.

8. System Accessories: Air filter rated for 97 percent efficiency at rated airflow, and combination filter/pressure-reducing station or separate filter and pressure-reducing station.
9. Refrigerated Air Dryer: Self-contained, refrigerated air dryer complete with heat exchangers, moisture separator, internal wiring and piping, and with manual bypass valve.
   a. Heat Exchangers: Air-to-refrigerant coils with centrifugal-type moisture separator and automatic trap assembly.
   b. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of 13 deg F (minus 11 deg C) at 20 psig (140 kPa), housed in steel cabinet with access door and panel.
   c. Accessories: Air-inlet temperature gage, air-inlet pressure gage, on-off switch, high-temperature light, power-on light, refrigerant gage on back, air-outlet temperature gage, air-outlet pressure gage, and with contacts for remote indication of power status and high-temperature alarm.
10. Desiccant Dryer: Obtains dew point in pneumatic air piping between compressor and tank at least 15 deg F (minus 9 deg C) below inlet-air dew point at design conditions.
11. Pressure Gages: Black letters on white background, 2-1/2 inches (64 mm) in diameter, flush or surface mounting, with front calibration screw to match sensor, and having a graduated scale in psig (kPa).
12. Instrument Pressure Gages: Black letters on white background, 1-1/2 inches (38 mm) in diameter, stem mounted, with suitable dial range.
13. Diaphragm Control and Instrument Valves: 1/4-inch (6-mm) forged-brass body with reinforced polytetrafluoroethylene diaphragm, stainless-steel spring, and color-coded phenolic handle.
14. Gage Cocks: Tee or level handle, bronze, rated for 125 psig (860 kPa).
15. Relays: For summing, reversing, and amplifying highest or lowest pressure selection; with adjustable I/O ratio.
16. Switches: With indicating plates and accessible adjustment; calibrated and marked.
17. Pressure Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve.
18. Particle Filters: Zinc or aluminum castings with 97 percent filtration efficiency at rated airflow, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.
19. Combination Filter/Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve; with threaded pipe connections, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.
20. Airborne Oil Filter: Filtration efficiency of 99.9 percent for airborne lubricating oil particles of 0.025 micron or larger.
21. Pressure Relief Valves: ASME rated and labeled.
   a. High Pressure: Size for installed capacity.
   b. Low Pressure: Size for installed capacity of pressure regulators and set at 20 percent above low pressure.
22. Pressure-Reducing Stations: Two parallel pressure regulators.

R. Control Cable
1. Electronic and fiber-optic cables for control wiring are specified in Division 16 Section "Communications Horizontal Cabling".

1.3 EXECUTION

A. Installation
1. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
2. Connect and configure equipment and software to achieve sequence of operation specified.

3. Mount compressor and tank unit on elastomeric mounts **OR** spring isolators with 1-inch (25 mm) static deflection **OR** restrained spring isolators with 1-inch (25-mm) static deflection, **as directed**. Vibration isolators are specified in Division 15 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Isolate air supply with wire-braid-reinforced rubber hose. Secure and anchor according to manufacturer's written instructions and seismic-control requirements.
   a. Pipe manual and automatic drains to nearest floor drain.
   b. Supply instrument air from compressor units through filter, pressure-reducing valve, and pressure relief valve, with pressure gages and shutoff and bypass valves.
4. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) **OR** 60 inches (1530 mm), **as directed**, above the floor.
   a. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
5. Install guards on thermostats in the following locations:
   a. Entrances.
   b. Public areas.
   c. Where indicated.
6. Install automatic dampers according to Division 15 Section "Duct Accessories".
7. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
8. Install labels and nameplates to identify control components according to Division 15 Section "Identification For Hvac Piping And Equipment".
9. Install hydronic instrument wells, valves, and other accessories according to Division 15 Section "Hydronic Piping".
10. Install steam and condensate instrument wells, valves, and other accessories according to Division 15 Section "Steam And Condensate Piping".
11. Install refrigerant instrument wells, valves, and other accessories according to Division 15 Section "Refrigerant Piping".
12. Install duct volume-control dampers according to Division 15 specifying air ducts.
13. Install electronic and fiber-optic cables according to Division 16 Section "Communications Horizontal Cabling".

B. Pneumatic Piping Installation
1. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.
   a. Install copper tubing with maximum unsupported length of 36 inches (915 mm), for tubing exposed to view.
   b. Install polyethylene tubing in metallic raceways or electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 16 Section "Underfloor Raceways For Electrical Systems".
2. Install terminal single-line connections, less than 18 inches (460 mm) in length, with copper or polyethylene tubing run inside flexible steel protection.
3. In concealed locations such as pipe chases and suspended ceilings with easy access, install copper **OR** polyethylene bundled and sheathed **OR** polyethylene tubing in electrical metallic, **as directed**, tubing. Electrical metallic tubing materials and installation requirements are specified in Division 16 Section "Raceways And Boxes".
4. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in electrical metallic tubing or vinyl-jacketed polyethylene tubing.
   a. Protect embedded-copper and vinyl-jacketed polyethylene tubing with electrical metallic tubing extending 6 inches (150 mm) above finished slab and 6 inches (150 mm) into slab. Pressure test tubing before and after pour for leak and pinch.
   b. Install polyethylene tubing in electrical metallic tubing extending 6 inches (150 mm) above floor line; pull tubing into electrical metallic tubing after pour.
5. Install tubing with sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Purge tubing with dry, oil-free compressed air before connecting control instruments.

a. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.

7. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.
8. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.

C. Electrical Wiring And Connection Installation

1. Install raceways, boxes, and cabinets according to Division 16 Section "Raceways And Boxes".
2. Install building wire and cable according to Division 16 Section "Conductors And Cables".
3. Install signal and communication cable according to Division 16 Section "Communications Horizontal Cabling".
   a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
   b. Install exposed cable in raceway.
   c. Install concealed cable in raceway.
   d. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
   e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
   f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
   g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
4. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
5. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

D. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
   a. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
   b. Test and adjust controls and safeties.
   c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
   d. Pressure test control air piping at 30 psig (207 kPa) or 1.5 times the operating pressure for 24 hours, with maximum 5-psig (35-kPa) loss.
   e. Pressure test high-pressure control air piping at 150 psig (1034 kPa) and low-pressure control air piping at 30 psig (207 kPa) for 2 hours, with maximum 1-psig (7-kPa) loss.
   f. Test calibration of pneumatic **OR** electronic, **as directed**, controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
   g. Test each point through its full operating range to verify that safety and operating control set points are as required.
   h. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
   i. Test each system for compliance with sequence of operation.
   j. Test software and hardware interlocks.
2. DDC Verification:
   a. Verify that instruments are installed before calibration, testing, and loop or leak checks.
   b. Check instruments for proper location and accessibility.
   c. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
   d. Check instrument tubing for proper fittings, slope, material, and support.
   e. Check installation of air supply for each instrument.

f. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
g. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
h. Check temperature instruments and material and length of sensing elements.
i. Check control valves. Verify that they are in correct direction.
j. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
k. Check DDC system as follows:
1) Verify that DDC controller power supply is from emergency power supply, if applicable.
2) Verify that wires at control panels are tagged with their service designation and approved tagging system.
3) Verify that spare I/O capacity has been provided.
4) Verify that DDC controllers are protected from power supply surges.

3. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. Adjusting
1. Calibrating and Adjusting:
a. Calibrate instruments.
b. Make three-point calibration test for both linearity and accuracy for each analog instrument.
c. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
d. Control System Inputs and Outputs:
1) Check analog inputs at 0, 50, and 100 percent of span.
2) Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
3) Check digital inputs using jumper wire.
4) Check digital outputs using ohmmeter to test for contact making or breaking.
5) Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
e. Flow:
1) Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
2) Manually operate flow switches to verify that they make or break contact.
f. Pressure:
1) Calibrate pressure transmitters at 0, 50, and 100 percent of span.
2) Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
g. Temperature:
1) Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
2) Calibrate temperature switches to make or break contacts.
h. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
i. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
j. Provide diagnostic and test instruments for calibration and adjustment of system.
k. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
2. Adjust initial temperature and humidity set points.
3. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

F. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

END OF SECTION 15910

SECTION 15910a - ENCLOSED CONTROLLERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for enclosed controllers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes the following enclosed controllers rated 600 V and less:
   a. Full-voltage manual.
   b. Full-voltage magnetic.
   c. Reduced-voltage magnetic.
   d. Reduced-voltage solid state.
   e. Multispeed.

C. Definitions
1. CPT: Control power transformer.
2. MCCB: Molded-case circuit breaker.
3. MCP: Motor circuit protector.
4. N.C.: Normally closed.
5. N.O.: Normally open.
6. OCPD: Overcurrent protective device.
7. SCR: Silicon-controlled rectifier.

D. Performance Requirements
1. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
2. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
   a. Show tabulations of the following:
      1) Each installed unit's type and details.
      2) Factory-installed devices.
      3) Nameplate legends.
      4) Short-circuit current rating of integrated unit.
      5) Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
      6) Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
   b. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

5. Field quality-control reports.
6. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. Include the following:
   a. Routine maintenance requirements for enclosed controllers and installed components.
   b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
   c. Manufacturer's written instructions for setting field-adjustable overload relays.
   d. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.
7. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
8. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

F. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
   a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.
4. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

G. Delivery, Storage, And Handling
1. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
2. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.

H. Project Conditions
1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
   b. Altitude: Not exceeding 6600 feet (2010 m).
2. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of electrical systems.
   b. Indicate method of providing temporary utilities.
   c. Do not proceed with interruption of electrical systems without Owner's written permission.
   d. Comply with NFPA 70E.

I. Coordination

1. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
3. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.2 PRODUCTS

A. Full-Voltage Controllers
1. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
   a. Configuration: Nonreversing **OR** Reversing **OR** Two speed, **as directed**.
   b. Flush **OR** Surface, **as directed**, mounting.
   c. Red **OR** Green, **as directed**, pilot light.
   d. Additional Nameplates: FORWARD and REVERSE for reversing switches **OR** HIGH and LOW for two-speed switches, **as directed**.
3. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
   a. Configuration: Nonreversing **OR** Two speed, **as directed**.
   b. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type **OR** melting alloy type, **as directed**.
   c. Flush **OR** Surface, **as directed**, mounting.
   d. Red **OR** Green, **as directed**, pilot light.
   e. Additional Nameplates: HIGH and LOW for two-speed controllers.
4. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
   a. Configuration: Nonreversing **OR** Reversing **OR** Two speed, **as directed**.
   b. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type **OR** melting alloy type, **as directed**.
   c. Flush **OR** Surface, **as directed**, mounting.
   d. Red **OR** Green, **as directed**, pilot light.
   e. Additional Nameplates: FORWARD and REVERSE for reversing controllers **OR** HIGH and LOW for two-speed controllers, **as directed**.
   f. N.O. **OR** N.C., **as directed**, auxiliary contact.
5. Magnetic Controllers: Full voltage, across the line, electrically held.
   a. Configuration: Nonreversing **OR** Reversing, **as directed**.
   b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
      1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
   c. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
   d. Control Circuits: 24 **OR** 120, **as directed**,-V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
      1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
   e. Melting Alloy Overload Relays:
      1) Inverse-time-current characteristic.

2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

f. Bimetallic Overload Relays:
1) Inverse-time-current characteristic.
2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
4) Ambient compensated.
5) Automatic resetting.

g. Solid-State Overload Relay:
1) Switch or dial selectable for motor running overload protection.
2) Sensors in each phase.
3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
5) Analog communication module.

h. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.

i. External overload reset push button.

6. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

a. Fusible Disconnecting Means:
1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

b. Nonfusible Disconnecting Means:
1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

c. MCP Disconnecting Means:
1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

d. MCCB Disconnecting Means:
1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.

B. Reduced-Voltage Magnetic Controllers
1. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
2. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
a. Configuration:
1) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
2) Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
3) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
c. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
d. Control Circuits: 24 **OR** 120, **as directed**,-V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
e. Melting Alloy Overload Relays:
1) Inverse-time-current characteristic.
2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
f. Bimetallic Overload Relays:
1) Inverse-time-current characteristic.
2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
4) Ambient compensated.
5) Automatic resetting.
g. Solid-State Overload Relay:
1) Switch or dial selectable for motor running overload protection.
2) Sensors in each phase.
3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
5) Analog communication module.
h. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
i. External overload reset push button.
3. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
a. Fusible Disconnecting Means:
1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
b. Nonfusible Disconnecting Means:
1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.

2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

c. MCP Disconnecting Means:
1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

d. MCCB Disconnecting Means:
1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.

C. Reduced-Voltage Solid-State Controllers
1. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.
2. Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
a. Configuration: Standard duty **OR** Severe duty, **as directed**; nonreversible **OR** reversible, **as directed**.
b. Starting Mode: Voltage ramping **OR** Current limit **OR** Torque control **OR** Torque control with voltage boost, **as directed**; field selectable, **as directed**.
c. Stopping Mode: Coast to stop **OR** Adjustable torque deceleration **OR** Adjustable braking, **as directed**; field selectable, **as directed**.
d. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
e. Shorting and Input Isolation, **as directed**, Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors, **as directed**.
f. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
g. Control Circuits: 24 **OR** 120, **as directed**,-V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
1) CPT Spare Capacity: 100 **OR** 200, **as directed**, VA.
h. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.

i. SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with **OR** without, **as directed**, external feedback from the motor or driven equipment.

j. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
   1) Adjusting motor full-load amperes, as a percentage of the controller's rating.
   2) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
   3) Adjusting linear acceleration and deceleration ramps, in seconds.
   4) Initial torque, as a percentage of the nominal motor torque.
   5) Adjusting torque limit, as a percentage of the nominal motor torque.
   6) Adjusting maximum start time, in seconds.
   7) Adjusting voltage boost, as a percentage of the nominal supply voltage.
   8) Selecting stopping mode, and adjusting parameters.
   9) Selecting motor thermal overload protection class between 5 and 30.
   10) Activating and de-activating protection modes.
   11) Selecting or activating communication modes.

k. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
   1) Controller Condition: Ready, starting, running, stopping.
   2) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
   3) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

l. Controller Diagnostics and Protection:
   1) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
   2) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
   3) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.
      OR
      Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

m. Remote Output Features:
   1) All outputs prewired to terminal blocks.
   2) Form C status contacts that change state when controller is running.
   3) Form C alarm contacts that change state when a fault condition occurs.

n. Optional Features:
   1) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc **OR** 4 to 20-mA dc, **as directed**.
   2) Additional field-assignable Form C contacts, as indicated, for alarm outputs.
   3) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   4) Full-voltage bypass contactor operating automatically **OR** manually, with NORMAL/BYPASS selector switch, **as directed**. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
   5) Melting Alloy Overload Relays:
      a) Inverse-time-current characteristic.
      b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

6) Bimetallic Overload Relays:
   a) Inverse-time-current characteristic.
   b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
   c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   d) Ambient compensated.
   e) Automatic resetting.
7) Solid-State Overload Relay:
   a) Switch or dial selectable for motor running overload protection.
   b) Sensors in each phase.
   c) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
   d) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
   e) Analog communication module.
8) N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
9) External overload reset push button.

3. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.
   a. Fusible Disconnecting Means:
      1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class L **OR** indicated, **as directed**, fuses.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
   b. MCP Disconnecting Means:
      1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
      4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
      5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
   c. MCCB Disconnecting Means:
      1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
      2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
      3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
      5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
   d. Molded-Case Switch Disconnecting Means:
      1) UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.

4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when molded-case switch has tripped.

D. Multispeed Magnetic Controllers

1. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
   a. Configuration: Nonreversing **OR** Reversing, **as directed**; consequent pole **OR** two winding, **as directed**.
   b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
      1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
   c. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
   d. Control Circuits: 24 **OR** 120, **as directed**,-V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
      1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
   e. Compelling relays shall ensure that motor will start only at low speed.
   f. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
   g. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
   h. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
   i. Melting Alloy Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   j. Bimetallic Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      4) Ambient compensated.
      5) Automatic resetting.
   k. Solid-State Overload Relay:
      1) Switch or dial selectable for motor running overload protection.
      2) Sensors in each phase.
      3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      5) Analog communication module.
   l. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
   m. External overload reset push button.
3. Combination Multispeed Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
   a. Fusible Disconnecting Means:
      1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

b. Nonfusible Disconnecting Means:
1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

c. MCP Disconnecting Means:
1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

d. MCCB Disconnecting Means:
1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.

E. Enclosures
1. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
a. Dry and Clean Indoor Locations: Type 1.
b. Outdoor Locations: Type 3R **OR** Type 4X, **as directed**.
c. Kitchen **OR** Wash-Down, **as directed**, Areas: Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: Type 4.
e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
f. Hazardous Areas Indicated on Drawings: Type 7 **OR** Type 9, **as directed**.

F. Accessories
1. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**,-duty, oiltight, **as directed**, type.
1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**, as indicated.
2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; colors as indicated; push to test, **as directed**.
3) Selector Switches: Rotary type.
b. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable **OR** resettable, **as directed**.
c. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
2. N.C. **OR** N.O. **OR** Reversible N.C./N.O., **as directed**, auxiliary contact(s).

3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
5. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 **OR** Type 4X **OR** Type 7 **OR** Type 9, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
6. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R **OR** Type 4X **OR** Type 12, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
7. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
8. Cover gaskets for Type 1 enclosures.
9. Terminals for connecting power factor correction capacitors to the line **OR** load, **as directed**, side of overload relays.
10. Spare control wiring terminal blocks, quantity as indicated; unwired **OR** wired, **as directed**.

1.3 EXECUTION

A. Examination
1. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
2. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Installation
1. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 16 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounted Controllers: Install enclosed controllers on 4-inch (100-mm) nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in each fusible-switch enclosed controller.
6. Install fuses in control circuits if not factory installed. Comply with requirements in Division 16 Section "Fuses".
7. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
8. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

9. Install power factor correction capacitors. Connect to the line **OR** load, **as directed**, side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
10. Comply with NECA 1.

C. Identification
1. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".
   a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   b. Label each enclosure with engraved nameplate.
   c. Label each enclosure-mounted control and pilot device.

D. Control Wiring Installation
1. Install wiring between enclosed controllers and remote devices and facility's central control system, **as directed**. Comply with requirements in Division 16 Section "Control-voltage Electrical Power Cables".
2. Bundle, train, and support wiring in enclosures.
3. Connect selector switches and other automatic-control selection devices where applicable.
   a. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
   b. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

E. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Acceptance Testing Preparation:
   a. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
   b. Test continuity of each circuit.
4. Tests and Inspections:
   a. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment, **as directed**.
   b. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
   c. Test continuity of each circuit.
   d. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
   e. Test each motor for proper phase rotation.
   f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
      1) Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
      2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Substantial Completion.

3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

5. Enclosed controllers will be considered defective if they do not pass tests and inspections.
6. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

F. Adjusting
1. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
2. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.
4. Set the taps on reduced-voltage autotransformer controllers at 50 **OR** 65 **OR** 80, **as directed**, percent.
5. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.
6. Set field-adjustable circuit-breaker trip ranges as specified in Division 16 Section "Overcurrent Protective Device Coordination", **as directed**.

G. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
2. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

H. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers, **as directed**.

END OF SECTION 15910a

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SECTION 15915 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for general-service packaged air compressors and receivers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Lubricated, reciprocating air compressors.
b. Oil-free, reciprocating air compressors.
c. Oilless, reciprocating air compressors.
d. Oil-free, rotary-screw air compressors.
e. Oil-flooded, rotary-screw air compressors.
f. Oil-free, rotary, sliding-vane air compressors.
g. Oil-sealed, rotary, sliding-vane air compressors.
h. Inlet-air filters.
i. Air-cooled, compressed-air aftercoolers.
j. Water-cooled, compressed-air aftercoolers.
k. Refrigerant compressed-air dryers.
l. Desiccant compressed-air dryers.
m. Computer interface cabinet.

C. Definitions
1. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm (actual L/s).
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
3. Standard Air: Free air at 68 deg F (20 deg C) and 1 atmosphere (29.92 in. Hg) before compression or expansion and measured in scfm (standard L/s).

D. Performance Requirements
1. Delegated Design: Design compressed-air equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated.
a. Wiring Diagrams: For power, signal, and control wiring.
2. Delegated-Design Submittal: For compressed-air equipment mounting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Detail fabrication and assembly of supports.
b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

3. Seismic Qualification Certificates: For compressed-air equipment, accessories, and components, from manufacturers.
4. Operation and Maintenance Data.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

1.2 PRODUCTS

A. General Requirements For Packaged Air Compressors And Receivers
1. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
2. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
   a. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
   b. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
   c. Control Voltage: 120-V ac or less, using integral control power transformer.
   d. Motor Overload Protection: Overload relay in each phase.
   e. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
   f. Automatic control switches to alternate lead-lag compressors for duplex **OR** sequence lead-lag compressors for multiplex, **as directed**, air compressors.
   g. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
   h. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
3. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
   a. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
   b. Interior Finish: Corrosion-resistant coating.
   c. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.
4. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

B. Lubricated, Reciprocating Air Compressors
1. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.
   a. Submerged gear-type oil pump.
   b. Oil filter.
   c. Combined high discharge-air temperature and low lubrication-oil pressure switch.
   d. Belt guard totally enclosing pulleys and belts.

C. Oil-Free, Reciprocating Air Compressors
1. Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber, lubricated crankcase, and of construction that prohibits oil from entering compression chamber.

a. Submerged gear-type oil pump.
b. Oil filter.
c. Combined high discharge-air temperature and low lubrication-oil pressure switch.
d. Belt guard totally enclosing pulleys and belts.

D. Oilless, Reciprocating Air Compressors
1. Compressor(s): Oilless (nonlubricated), reciprocating-piston type, with sealed oil-free bearings, that will deliver air of quality equal to intake air.
a. High discharge-air temperature switch.
b. Belt guard totally enclosing pulleys and belts.

E. Oil-Free, Rotary-Screw Air Compressors
1. Compressor(s): Oil-free, rotary-screw type with nonlubricated helical screws and lubricated gear box, and of construction that prohibits oil from entering compression chamber.
a. Coupling: Nonlubricated, flexible type.
b. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package prepiped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
c. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.
d. Air/Coolant Receiver and Separation System: 150-psig- (1035-kPa-) rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
e. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig (345 and 690 kPa). Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

F. Oil-Flooded, Rotary-Screw Air Compressors
1. Compressor(s): Oil-flooded, rotary-screw type with lubricated helical screws and lubricated gear box.
a. Coupling: Nonlubricated, flexible type.
b. Cooling/Lubrication System: Unit-mounted, air-cooled exchanger package prepiped to unit; with air pressure circulation system with coolant stop valve, full-flow coolant filter, and thermal bypass valve.
c. Air Filter: Dry type, with maintenance indicator and cleanable replaceable filter element.
d. Air/Coolant Receiver and Separation System: 150-psig- (1035-kPa-) rated steel tank with ASME safety valve, coolant-level gage, multistage air-coolant separator element, minimum pressure valve, blowdown valve, discharge check valve, coolant stop valve, full-flow coolant filter, and thermal bypass valve.
e. Capacity Control: Capacity modulation between zero and 100 percent air delivery, with operating pressures between 50 and 100 psig (345 and 690 kPa). Include necessary control to hold constant pressure. When air demand is zero, unload compressor by using pressure switch and blowdown valve.

G. Oil-Free, Rotary, Sliding-Vane Air Compressors
1. Compressor(s): Oil-free, nonpulsating, rotary, sliding-vane type with nonlubricated sliding vanes.
a. Cleanable inlet screens.
b. Outlet silencers on discharge connections.

H. Oil-Sealed, Rotary, Sliding-Vane Air Compressors
1. Compressor(s): Nonpulsating, rotary, sliding-vane type with oil-sealed sliding vanes.
a. Cleanable inlet screens.
b. Outlet silencers and oil-mist separators on discharge connections.

I. Inlet-Air Filters

1. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
   a. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
   b. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.
2. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.
   a. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
   b. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

J. Air-Cooled, Compressed-Air Aftercoolers
1. Description: Electric-motor-driven, fan-operation, finned-tube unit; rated at 250 psig (1725 kPa) and leak tested at 350-psig (2415-kPa) minimum air pressure; in capacities indicated. Size units to cool compressed air in compressor-rated capacities to 10 deg F (6 deg C) above summertime maximum ambient temperature. Include moisture separator and automatic drain.

K. Water-Cooled, Compressed-Air Aftercoolers
1. Description: Shell and tube unit, rated at 250 psig (1725 kPa) and leak tested at 350-psig (2415-kPa) minimum air pressure, in capacities indicated. Include moisture separator and automatic drain.

L. Refrigerant Compressed-Air Dryers
1. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 deg F (2 deg C), 100-psig (690-kPa) air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

M. Desiccant Compressed-Air Dryers
1. Description: Twin-tower unit with purge system, mufflers, and capability to deliver plus 10 deg F (minus 12 deg C), 100-psig (690-kPa) air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

N. Computer Interface Cabinet
1. Description:
   a. Wall mounting.
   b. Welded steel with white enamel finish.
   c. Gasketed door.
   d. Grounding device.
   e. Factory-installed, signal circuit boards.
   f. Power transformer.
   g. Circuit breaker.
   h. Wiring terminal board.
   i. Internal wiring capable of interfacing 20 alarm signals.

O. Motors
1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements For Plumbing Equipment".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 15.

1.3 EXECUTION

A. Equipment Installation
1. Equipment Mounting:
a. Install air compressors, aftercoolers, and air dryers on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
1) Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
2) Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5) Install anchor bolts to elevations required for proper attachment to supported equipment.
b. Install air compressors, aftercoolers, and air dryers using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
1) Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
c. Install air compressors, aftercoolers, and air dryers on vibration isolation inertia bases. Comply with requirements specified in Division 15 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment".
d. Install air compressors, aftercoolers, and air dryers on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
1) Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4) Install anchor bolts to elevations required for proper attachment to supported equipment.
e. Install water-cooled, compressed-air aftercoolers and desiccant compressed-air dryers on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
1) Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2) For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3) Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4) Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Install compressed-air equipment anchored to substrate.
3. Arrange equipment so controls and devices are accessible for servicing.

4. Maintain manufacturer's recommended clearances for service and maintenance.
5. Install the following devices on compressed-air equipment:
   a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
   b. Pressure Regulators: Install downstream from air compressors and dryers.
   c. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

B. Connections
1. Comply with requirements for piping specified in Division 15 Section "General-service Compressed-air Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.

C. Identification
1. Identify general-service air compressors and components. Comply with requirements for identification specified in Division 15 Section "Identification For Plumbing Piping And Equipment".

D. Startup Service
1. Perform startup service.
   a. Complete installation and startup checks according to manufacturer's written instructions.
   b. Check for lubricating oil in lubricated-type equipment.
   c. Check belt drives for proper tension.
   d. Verify that air-compressor inlet filters and piping are clear.
   e. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
   f. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure but not higher than rating of system components.
   g. Check for proper seismic restraints.
   h. Drain receiver tanks.
   i. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   j. Test and adjust controls and safeties.

E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air compressors, aftercoolers, and air dryers.

END OF SECTION 15915

Task	Specification	Specification Description
15915	15910	HVAC Instrumentation And Controls
15917	15910	HVAC Instrumentation And Controls

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NEW YORK CITY DEPARTMENT OF DESIGN + CONSTRUCTION

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Technical Specifications

VOLUME V of V
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SECTION 16101 - ELECTRICAL IDENTIFICATION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for electrical identification. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Identification for raceways.
b. Identification of power and control cables.
c. Identification for conductors.
d. Underground-line warning tape.
e. Warning labels and signs.
f. Instruction signs.
g. Equipment identification labels.
h. Miscellaneous identification products.

C. Submittals
1. Product Data: For each electrical identification product indicated.
2. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
3. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

D. Quality Assurance
1. Comply with ANSI A13.1 and IEEE C2, **as directed**.
2. Comply with NFPA 70.
3. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
4. Comply with ANSI Z535.4 for safety signs and labels.
5. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.2 PRODUCTS

A. Power Raceway Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
2. Colors for Raceways Carrying Circuits at 600 V or Less:
a. Black letters on an orange field.
b. Legend: Indicate voltage and system or service type, **as directed**.
3. Colors for Raceways Carrying Circuits at More Than 600 V:
a. Black letters on an orange field.
b. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
4. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

5. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
6. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
7. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers diagonally over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stop stripes at legends.
8. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
9. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) **OR** 0.015 inch (0.38 mm), **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
      OR
      Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

B. Armored And Metal-Clad Cable Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
2. Colors for Raceways Carrying Circuits at 600 V and Less:
   a. Black letters on an orange field.
   b. Legend: Indicate voltage and system or service type, **as directed**.
3. Colors for Raceways Carrying Circuits at More Than 600 V:
   a. Black letters on an orange field.
   b. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
4. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
   OR
   Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

C. Power And Control Cable Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
2. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
3. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
4. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) **OR** 0.015 inch (0.38 mm), **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
      OR
      Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
5. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

6. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Conductor Identification Materials
1. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
2. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
3. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
4. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
5. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
6. Write-On Tags: Polyester tag, 0.010 inch (0.25 mm) **OR** 0.015 inch (0.38 mm), **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
   a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
      OR
      Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

E. Floor Marking Tape
1. 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.

F. Underground-Line Warning Tape
1. Tape:
   a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
   b. Printing on tape shall be permanent and shall not be damaged by burial operations.
   c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
2. Color and Printing:
   a. Comply with ANSI Z535.1 through ANSI Z535.5.
   b. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
   c. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.
3. Tag: Type I:
   a. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Thickness: 4 mils (0.1 mm).
   c. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
   d. 3-Inch (75-mm) Tensile According to ASTM D 882: 30 lbf (133.4 N), and 2500 psi (17.2 MPa).
4. Tag: Type II:
   a. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Thickness: 12 mils (0.3 mm).
   c. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).

d. 3-Inch (75-mm) Tensile According to ASTM D 882: 400 lbf (1780 N), and 11,500 psi (79.2 MPa).

5. Tag: Type ID:
   a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Overall Thickness: 5 mils (0.125 mm).
   c. Foil Core Thickness: 0.35 mil (0.00889 mm).
   d. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
   e. 3-Inch (75-mm) Tensile According to ASTM D 882: 70 lbf (311.3 N), and 4600 psi (31.7 MPa).
6. Tag: Type IID:
   a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
   b. Overall Thickness: 8 mils (0.2 mm).
   c. Foil Core Thickness: 0.35 mil (0.00889 mm).
   d. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
   e. 3-Inch (75-mm) Tensile According to ASTM D 882: 300 lbf (1334 N), and 12,500 psi (86.1 MPa).

G. Warning Labels And Signs
1. Comply with NFPA 70 and 29 CFR 1910.145.
2. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
3. Baked-Enamel Warning Signs:
   a. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
   b. 1/4-inch (6.4-mm) grommets in corners for mounting.
   c. Nominal size, 7 by 10 inches (180 by 250 mm).
4. Metal-Backed, Butyrate Warning Signs:
   a. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
   b. 1/4-inch (6.4-mm) grommets in corners for mounting.
   c. Nominal size, 10 by 14 inches (250 by 360 mm).
5. Warning label and sign shall include, but are not limited to, the following legends:
   a. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
   b. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

H. Instruction Signs
1. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
   a. Engraved legend with black letters on white face.
   b. Punched or drilled for mechanical fasteners.
   c. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
2. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
3. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

I. Equipment Identification Labels
1. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
2. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.
3. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
4. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
5. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

J. Cable Ties
1. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
   a. Minimum Width: 3/16 inch (5 mm).
   b. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
   c. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   d. Color: Black except where used for color-coding.
2. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
   a. Minimum Width: 3/16 inch (5 mm).
   b. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
   c. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
   d. Color: Black.
3. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
   a. Minimum Width: 3/16 inch (5 mm).
   b. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
   c. UL 94 Flame Rating: 94V-0.
   d. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
   e. Color: Black.

K. Miscellaneous Identification Products
1. Paint: Comply with requirements in Division 07 for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
2. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

1.3 EXECUTION

A. Installation
1. Verify identity of each item before installing identification products.
2. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
3. Apply identification devices to surfaces that require finish after completing finish work.
4. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
5. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
6. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot

(15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

7. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
8. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
   a. Outdoors: UV-stabilized nylon.
   b. In Spaces Handling Environmental Air: Plenum rated.
9. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
10. Painted Identification: Comply with requirements in Division 07 for surface preparation and paint application.

B. Identification Schedule
1. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch-(100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:
   a. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
   b. Wall surfaces directly external to raceways concealed within wall.
   c. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
2. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl **OR** Snap-around, **as directed**, labels. Install labels at 10-foot (3-m) **OR** 30-foot (10-m), **as directed**, maximum intervals.
3. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label **OR** self-adhesive vinyl tape applied in bands, **as directed**. Install labels at 10-foot (3-m) **OR** 30-foot (10-m), **as directed**, maximum intervals.
4. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
   a. Emergency Power.
   b. Power.
   c. UPS.
5. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
   a. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
      1) Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
      2) Colors for 208/120-V Circuits:
         a) Phase A: Black.
         b) Phase B: Red.
         c) Phase C: Blue.
      3) Colors for 480/277-V Circuits:
         a) Phase A: Brown.
         b) Phase B: Orange.
         c) Phase C: Yellow.
      4) Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where

splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

6. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags **OR** nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation, **as directed**.
7. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
8. Conductors to Be Extended in the Future: Attach write-on tags **OR** marker tape, **as directed**, to conductors and list source.
9. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
   a. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
   b. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
   c. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
10. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
    a. Limit use of underground-line warning tape to direct-buried cables.
    b. Install underground-line warning tape for both direct-buried cables and cables in raceway.
11. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
12. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels **OR** Baked-enamel warning signs **OR** Metal-backed, butyrate warning signs, **as directed**.
    a. Comply with 29 CFR 1910.145.
    b. Identify system voltage with black letters on an orange background.
    c. Apply to exterior of door, cover, or other access.
    d. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
       1) Power transfer switches.
       2) Controls with external control power connections.
13. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
14. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer **OR** load shedding, **as directed**.
15. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
    a. Labeling Instructions:
       1) Indoor Equipment: Adhesive film label **OR** Adhesive film label with clear protective overlay **OR** Self-adhesive, engraved, laminated acrylic or melamine label **OR** Engraved, laminated acrylic or melamine label, **as directed**. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
       2) Outdoor Equipment: Engraved, laminated acrylic or melamine label **OR** Stenciled legend 4 inches (100 mm) high, **as directed**.

3) Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
4) Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

b. Equipment to Be Labeled:
1) Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved **OR** engraved, **as directed**, laminated acrylic or melamine label.
2) Enclosures and electrical cabinets.
3) Access doors and panels for concealed electrical items.
4) Switchgear.
5) Switchboards.
6) Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
7) Substations.
8) Emergency system boxes and enclosures.
9) Motor-control centers.
10) Enclosed switches.
11) Enclosed circuit breakers.
12) Enclosed controllers.
13) Variable-speed controllers.
14) Push-button stations.
15) Power transfer equipment.
16) Contactors.
17) Remote-controlled switches, dimmer modules, and control devices.
18) Battery-inverter units.
19) Battery racks.
20) Power-generating units.
21) Monitoring and control equipment.
22) UPS equipment.

END OF SECTION 16101

SECTION 16101a - PANELBOARDS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for panelboards. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Distribution panelboards.
b. Lighting and appliance branch-circuit panelboards.
c. Load centers.
d. Electronic-grade panelboards.

C. Definitions
1. SVR: Suppressed voltage rating.
2. TVSS: Transient voltage surge suppressor.

D. Performance Requirements
1. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For each panelboard and related equipment.
a. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
b. Detail enclosure types and details for types other than NEMA 250, Type 1.
c. Detail bus configuration, current, and voltage ratings.
d. Short-circuit current rating of panelboards and overcurrent protective devices.
e. Include evidence of NRTL listing for series rating of installed devices.
f. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
g. Include wiring diagrams for power, signal, and control wiring.
h. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
3. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Panelboard Schedules: For installation in panelboards.
5. Operation and maintenance data

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA PB 1.
3. Comply with NFPA 70.

G. Delivery, Storage, And Handling
1. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
2. Handle and prepare panelboards for installation according to NECA 407 **OR** NEMA PB 1.

H. Project Conditions
1. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of electric service.
   b. Do not proceed with interruption of electric service without Owner's written permission.
   c. Comply with NFPA 70E.

I. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. General Requirements For Panelboards
1. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
2. Enclosures: Flush **OR** Surface **OR** Flush- and surface, **as directed**,-mounted cabinets.
   a. Rated for environmental conditions at installed location.
      1) Indoor Dry and Clean Locations: NEMA 250, Type 1.
      2) Outdoor Locations: NEMA 250, Type 3R.
      3) Kitchen or Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
      4) Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
      5) Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5 **OR** Type 12, **as directed**.
   b. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
   c. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
   d. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   e. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
   f. Finishes:
      1) Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
      2) Back Boxes: Galvanized steel **OR** Same finish as panels and trim, **as directed**.
      3) Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
   g. Directory Card: Inside panelboard door, mounted in transparent card holder **OR** metal frame with transparent protective cover, **as directed**.
3. Incoming Mains Location: Top **OR** Bottom **OR** Top and bottom, **as directed**.
4. Phase, Neutral, and Ground Buses:
   a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.

b. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
c. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
d. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
e. Split Bus: Vertical buses divided into individual vertical sections.

5. Conductor Connectors: Suitable for use with conductor material and sizes.
   a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.
   b. Main and Neutral Lugs: Compression **OR** Mechanical, **as directed**, type.
   c. Ground Lugs and Bus-Configured Terminators: Compression **OR** Mechanical, **as directed**, type.
   d. Feed-Through Lugs: Compression **OR** Mechanical, **as directed**, type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   e. Subfeed (Double) Lugs: Compression **OR** Mechanical, **as directed**, type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   f. Gutter-Tap Lugs: Compression **OR** Mechanical, **as directed**, type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
   g. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
6. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
7. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
8. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include size and type of allowable upstream and branch devices, listed and labeled for series-connected short-circuit rating by an NRTL.
9. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

B. Distribution Panelboards
1. Panelboards: NEMA PB 1, power and feeder distribution type.
2. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   a. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
3. Mains: Circuit breaker **OR** Fused switch **OR** Lugs only, **as directed**.
4. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Plug-in **OR** Bolt-on, **as directed**, circuit breakers.
5. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
6. Branch Overcurrent Protective Devices: Fused switches.
7. Contactors in Main Bus: NEMA ICS 2, Class A, electrically **OR** mechanically, **as directed**, held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   a. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
   b. External Control-Power Source: 120-V branch circuit **OR** 24-V control circuit, **as directed**.

C. Lighting And Appliance Branch-Circuit Panelboards
1. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
2. Mains: Circuit breaker **OR** Lugs only, **as directed**.
3. Branch Overcurrent Protective Devices: Plug-in **OR** Bolt-on, **as directed**, circuit breakers, replaceable without disturbing adjacent units.
4. Contactors in Main Bus: NEMA ICS 2, Class A, electrically **OR** mechanically, **as directed**, held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

a. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
b. External Control-Power Source: 120-V branch circuit **OR** 24-V control circuit, **as directed**.

5. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
6. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

D. Load Centers
1. Load Centers: Comply with UL 67.
2. Mains: Circuit breaker **OR** Lugs only, **as directed**.
3. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.
4. Conductor Connectors: Mechanical type for main, neutral, and ground lugs and buses.

E. Electronic-Grade Panelboards
1. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
2. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
3. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
4. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
5. Buses:
   a. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
   b. Copper equipment and isolated ground buses.
6. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in **OR** wired-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.
   a. Accessories:
      1) Fuses rated at 200-kA interrupting capacity.
      2) Fabrication using bolted compression lugs for internal wiring.
      3) Integral disconnect switch.
      4) Redundant suppression circuits.
      5) Redundant replaceable modules.
      6) Arrangement with wire connections to phase buses, neutral bus, and ground bus.
      7) LED indicator lights for power and protection status.
      8) Audible alarm, with silencing switch, to indicate when protection has failed.
      9) Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
      10) Four **OR** Six, **as directed**,-digit, transient-event counter set to totalize transient surges.
   b. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
   c. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
      1) Line to Neutral: 70,000 A.
      2) Line to Ground: 70,000 A.
      3) Neutral to Ground: 50,000 A.
   d. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
   e. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**,-V, three-phase, four-wire circuits shall be as follows:

1) Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
2) Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
3) Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.

f. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:
1) Line to Neutral: 400 V.
2) Line to Ground: 400 V.
3) Neutral to Ground: 400 V.

g. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
1) Line to Neutral: 400 V, 800 V from high leg.
2) Line to Ground: 400 V.
3) Neutral to Ground: 400 V.

h. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
1) Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
2) Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

F. Disconnecting And Overcurrent Protective Devices

1. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.

a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.

b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
1) Instantaneous trip.
2) Long- and short-time pickup levels.
3) Long- and short-time time adjustments.
4) Ground-fault pickup level, time delay, and I^2t response.

d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

e. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

f. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).

g. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.

h. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
1) Standard frame sizes, trip ratings, and number of poles.
2) Lugs: Compression **OR** Mechanical, **as directed**, style, suitable for number, size, trip ratings, and conductor materials.
3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

5) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring And Control".
6) Shunt Trip: 120 **OR** 24, **as directed**,-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
7) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional **OR** with field-adjustable 0.1- to 0.6-second, **as directed**, time delay.
8) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
9) Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
11) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
12) Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
13) Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on **OR** off, **as directed**, position.
14) Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
   a. Fuses, and Spare-Fuse Cabinet: Comply with requirements specified in Division 16 Section "Fuses".
   b. Fused Switch Features and Accessories: Standard ampere ratings and number of poles.
   c. Auxiliary Contacts: One **OR** Two, **as directed**, normally open and normally closed contact(s) that operate with switch handle operation.

G. Panelboard Suppressors
1. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
   a. Accessories:
      1) LED indicator lights for power and protection status.
      2) Audible alarm, with silencing switch, to indicate when protection has failed.
      3) One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.
2. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, plug-in **OR** wired-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
   a. Accessories:
      1) Fuses rated at 200-kA interrupting capacity.
      2) Fabrication using bolted compression lugs for internal wiring.
      3) Integral disconnect switch.
      4) Redundant suppression circuits.
      5) Redundant replaceable modules.
      6) Arrangement with wire connections to phase buses, neutral bus, and ground bus.
      7) LED indicator lights for power and protection status.
      8) Audible alarm, with silencing switch, to indicate when protection has failed.
      9) Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position

on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

10) Four **OR** Six, **as directed**,-digit, transient-event counter set to totalize transient surges.

b. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.

c. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.

1) Line to Neutral: 70,000 A.
2) Line to Ground: 70,000 A.
3) Neutral to Ground: 50,000 A.

d. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

e. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**,-V, three-phase, four-wire circuits shall be as follows:

1) Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
2) Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
3) Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.

f. Protection modes and UL 1449 SVR for 240/120-V, single-phase, three-wire circuits shall be as follows:

1) Line to Neutral: 400 V.
2) Line to Ground: 400 V.
3) Neutral to Ground: 400 V.

g. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

1) Line to Neutral: 400 V, 800 V from high leg.
2) Line to Ground: 400 V.
3) Neutral to Ground: 400 V.

h. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

1) Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
2) Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

H. Accessory Components And Features

1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
2. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

1.3 EXECUTION

A. Installation

1. Install panelboards and accessories according to NECA 407 **OR** NEMA PB 1.1, **as directed**.
2. Equipment Mounting: Install panelboards on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".

a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.

b. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to panelboards.
e. Attach panelboard to the vertical finished or structural surface behind the panelboard.

3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
4. Comply with mounting and anchoring requirements specified in Division 16 Section "Hangers And Supports For Electrical Systems".
5. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
6. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
7. Install overcurrent protective devices and controllers not already factory installed.
   a. Set field-adjustable, circuit-breaker trip ranges.
8. Install filler plates in unused spaces.
9. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
10. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing, **as directed**.
11. Comply with NECA 1.

B. Identification
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 16 Section "Electrical Identification".
2. Create a directory to indicate installed circuit loads after balancing panelboard loads, **as directed**; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
3. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 16 Section "Electrical Identification".
4. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 16 Section "Electrical Identification".

C. Field Quality Control
1. Perform tests and inspections.
2. Acceptance Testing Preparation:
   a. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
   b. Test continuity of each circuit.
3. Tests and Inspections:
   a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   c. Perform the following infrared scan tests and inspections and prepare reports:
      1) Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
      2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
      3) Instruments and Equipment:

a) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Panelboards will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Adjusting
1. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
2. Set field-adjustable circuit-breaker trip ranges as indicated **OR** as specified in Division 16 Section "Overcurrent Protective Device Coordination", **as directed**.
3. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
   a. Measure as directed during period of normal system loading.
   b. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
   c. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
   d. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

E. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 16101a

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Task	Specification	Specification Description
16102	16120c	Conductors And Cables

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SECTION 16112 - ENCLOSED BUS ASSEMBLIES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for enclosed bus assemblies. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Feeder-bus assemblies.
b. Plug-in bus assemblies.
c. Bus plug-in devices.

C. Definitions
1. TVSS: Transient voltage surge suppressor.

D. Submittals
1. Shop Drawings: For each type of bus assembly **OR** bus assembly and plug-in device, **as directed**.
a. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
b. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers and weather barriers.
c. Indicate required clearances, method of field assembly, and location and size of each field connection.
d. Detail connections to switchgear, switchboards, transformers, and panelboards.
e. Wiring Diagrams: Power and signal **OR** and control, **OR** signal, and control, **as directed**, wiring.
f. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
1) Design Calculations: Calculate requirements for selecting seismic restraints.
2) Detail fabrication, including anchorages and attachments to structure and to supported equipment.
2. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:
a. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
b. Clearances for access above and to the side of enclosed bus assemblies.
c. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
d. Support locations, type of support, and weight on each support.
3. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
4. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.
5. Manufacturer Seismic Qualification Certification: Submit certification that enclosed bus assemblies, plug-in devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems" Include the following:
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
1) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

6. Qualification Data: For professional engineer and testing agency.
7. Field quality-control test reports.
8. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

E. Quality Assurance

1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

   a. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 1.3.

2. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
3. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Comply with NEMA BU 1, "Busways."
6. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

G. Project Conditions

1. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding 122 deg F (50 deg C) **OR** 140 deg F (60 deg C), **as directed**.

H. Coordination

1. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 02.

1.2 PRODUCTS

A. Enclosed Bus Assemblies

1. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.

   a. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces

defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems" when mounting provisions and attachments are anchored to building structure

b. Voltage: 120/208 **OR** 240 **OR** 480 **OR** 277/480, **as directed**, V; 3 phase; 100 **OR** 200 **OR** percent neutral capacity, **as directed**.

c. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.

d. Bus Materials: Current-carrying copper **OR** aluminum, **as directed**, conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.

e. Ground:

1) 50 percent capacity integral with housing.

2) 50 percent capacity internal bus bars of material matching bus material.

3) 50 percent capacity isolated, internal bus bar of material matching bus material.

f. Enclosure: Steel with manufacturer's standard finish **OR** Aluminum with manufacturer's standard finish **OR** Weatherproof, steel or aluminum with manufacturer's standard finish, sealed seams, drains, and removable closures, **as directed**.

g. Fittings and Accessories: Manufacturer's standard.

h. Mounting: Arranged flat, edgewise, or vertically without derating.

2. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.

a. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for switchboards with reinforcement strong enough to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems" when mounting provisions and attachments are anchored to building structure.

b. Voltage: 120/208 **OR** 240 **OR** 480 **OR** 277/480, **as directed**, V; 3 phase; 100 **OR** 200 **OR** percent neutral capacity, **as directed**.

c. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.

d. Bus Materials: Current-carrying copper **OR** aluminum, **as directed**, conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.

e. Ground:

1) 50 percent capacity integral with housing.

2) 50 percent capacity internal bus bar of material matching bus material.

3) 50 percent capacity isolated, internal bus bar of material matching bus material.

f. Enclosure: Steel, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings **OR** Aluminum, with manufacturer's standard finish, plug-in openings 24 inches (610 mm) o.c., and hinged covers over unused openings, **as directed**.

g. Fittings and Accessories: Manufacturer's standard.

h. Mounting: Arranged flat, edgewise, or vertically without derating.

B. Plug-In Devices

1. Fusible Switches: NEMA KS 1, heavy duty; with R-type rejection **OR** J-type **OR** L-type, **as directed**, fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. See Division 16 Section "Fuses" for fuses and fuse installation requirements.

2. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.

3. TVSS: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate TVSS from busway. TVSS product and installation requirements are specified in Division 16 Section "Transient Voltage Suppression."

4. Motor Controllers: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

a. Control Circuit: 120 V; obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

b. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.
   1) Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with R-type rejection **OR** J-type, **as directed**, fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction. See Division 16 Section "Fuses" for fuses and fuse installation requirements.
      OR
      Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
      OR
      Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

c. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic. Overload relays shall have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

d. Adjustable Overload Relay: Dipswitch selected for motor running overload protection with NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Adjustable overload relays shall have Class II ground-fault protection with start and run delays to prevent nuisance trip on starting.

5. Multispeed Motor Controllers: Match controller to motor type, application, and number of speeds; include the following accessories:
   a. Compelling relay ensures motor starts only at low speed.
   b. Accelerating relay ensures properly timed acceleration through speeds lower than that selected.
   c. Decelerating relay ensures automatically timed deceleration through each speed.

6. Accessories: Hookstick operator, adjustable to maximum extension of 14 feet (4.3 m), **as directed**.

1.3 EXECUTION

A. Installation

1. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
   a. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
   b. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
   c. Support bus assembly to prevent twisting from eccentric loading.
   d. Support bus assembly with not less than 3/8-inch (10-mm) steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
   e. Fasten supports securely to building structure according to Division 16 Section "Hangers And Supports For Electrical Systems".
2. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
3. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Section "Through-penetration Firestop Systems".

4. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Division 07 Section "Joint Sealants" for materials and application.
5. Install a concrete curb at least 4 inches (100 mm) high around bus-assembly floor penetrations.
6. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
7. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.
8. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

B. Connections
1. Ground equipment according to Division 16 Section "Grounding And Bonding".
2. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
   a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Remove and replace units that do not pass tests and inspections and retest as specified above.
4. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of bus assembly including joints and plug-in units.
   a. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
   b. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Substantial Completion.
   c. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
5. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

D. Adjusting
1. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings, **as directed**, as indicated.

E. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

F. Protection
1. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 16112

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SECTION 16113 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of underfloor raceways for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Flat-top, single-channel, underfloor raceways.
b. Flat-top, multichannel, underfloor raceways.
c. Flush, flat-top underfloor raceways.
d. Cellular metal underfloor raceways.
e. Trench-type underfloor raceways.
f. Electrical connection components for precast concrete, hollow-core, floor decks.
g. Electrical connection components for electrified cellular steel floor decks.
h. Service fittings.

C. Definitions
1. Flush Outlet: Underfloor raceway outlet installed so the top of the fixed portions of the receptacles, jacks, and connector assemblies is located approximately at the surface of the floor or floor covering, and with the bodies of connected plugs exposed above the surface of the floor.
2. Flush Underfloor Raceway: Rectangular cross-section, flat-top raceway installed with the top of the raceway flush with the surface of the concrete in which it is embedded.
3. Header Raceway: Rectangular cross-section, single-channel or multichannel, underfloor raceway arranged as feeder raceway to bring wires and cables to service raceways from panelboards and communication terminal components.
4. Recessed Outlet: Underfloor raceway outlet installed with the top of the fixed portion of the connector assemblies located below the surface of the floor or floor covering and arranged to receive plug connectors with the bodies of the plugs concealed below the floor level.
5. Service Raceway: Underfloor distribution raceway providing direct connection to service fittings using preset or afterset inserts.
6. Trench Header: Trench-type raceway arranged as feeder raceway to bring wires and cables to service raceways from panelboards and communication terminal equipment.
7. Underfloor Raceway: A conduit, duct, or cell assembly, or trench located within the floor material or with its top at the floor surface.

D. Submittals
1. Product Data: For underfloor raceway components, fittings, and accessories.
2. Shop Drawings: For underfloor raceways. Include floor plans, assembly drawings, sections, and details.
a. Identify components and accessories such as expansion-joint assemblies, straight raceway lengths, preset and afterset inserts, and service fittings.
b. Provide dimensions locating raceway header and distribution elements. Include spacing between preset inserts and between preset inserts and ends of duct runs, walls, columns, junction boxes, and header duct connections.
c. Show connections between raceway elements and relationships between components and adjacent structural and architectural elements including slab reinforcement, floor finish work, permanent partitions, architectural module lines, and pretensioning or post-tensioning components.

d. Indicate height of preset inserts, junction boxes, and raceways coordinated with depth of concrete slab and floor fill.
e. Indicate thickening of slabs where required for adequate encasement of raceway components.
f. Document coordination of exposed components with floor-covering materials to ensure that fittings and trim are suitable for indicated floor-covering material.
g. Revise locations from those indicated in the Contract Documents, as required to suit field conditions and to ensure a functioning layout. Identify proposed deviations from the Contract Documents.
h. Show details of connections and terminations of underfloor raceways at panelboards and communication terminal equipment in equipment rooms, wire closets, and similar spaces.
i. Identify those cells of cellular floor deck that are to be connected and fitted for the following underfloor distribution:
1) Power.
2) Voice.
3) Data.
4) Signal.
5) Communications.

3. Samples: For typical underfloor raceway products, in specified finish, including the following:
a. Service fittings and flush and recessed outlet and junction-box covers.
b. A section of each service raceway configuration with specified preset insert and service fitting installed.
c. A junction box of each size and type for use with underfloor raceway.
d. A section of each header raceway configuration, complete with provisions for connection with service raceway.
e. A section of trench-type raceway, complete with cover and required trim.
f. A junction box of each size and type, complete with cover and trim.

4. Operation and Maintenance Data: For underfloor raceways, to include in emergency, operation, and maintenance manuals. Include the following:
a. Manufacturer's written instructions for locating preset inserts and for installing afterset inserts.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Flat-Top, Single-Channel, Underfloor Raceways
1. Description:
a. Material: Steel.
b. Cross-Section Shape: Rectangular.
c. Number of Levels: One **OR** Two, **as directed**.
d. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.

2. Service Raceways: Fitted with preset inserts.
a. Nominal Raceway Dimensions:
1) Depth: 1-1/2 inches (38 mm).
2) Power Service Raceway Width: 3-1/2 inches (90 mm).
3) Communication Service Raceway Width: 3-1/2 inches (90 mm) **OR** 6-1/2 inches (165 mm), **as directed**.

b. Number of Single-Channel Raceways per Run: One **OR** Two **OR** Three **OR** Four **OR** Five, **as directed**, unless otherwise indicated.
c. Preset Inserts: Rectangular **OR** Round, **as directed**.
1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed,** o.c.
2) Size: Rectangular dimensions as required to accommodate mounting and connection of flush-mounted, duplex receptacle or dual communication-jack or connector service fitting.
3) Size: 2 inches (50 mm) in diameter.
4) Equip each insert with a disposable cover and select insert height so cover is 1/8 inch (3 mm) below surface of concrete.
5) Arrange insert for optional attachment of flush-, surface-, or wiring- extension service fitting to replace disposable cover.

3. Header Raceways: Single channel, without preset inserts (blank raceway).
a. Nominal Raceway Dimensions:
1) Depth: 1-1/2 inches (38 mm).
2) Power Header Raceway Width: 3-1/2 inches (90 mm).
3) Communication Header Raceway Width: 3-1/2 inches (90 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
b. Arrangement: In same plane as **OR** Below, **as directed**, service raceways.
c. Connections: Arranged to connect with service raceways at single-level **OR** two-level, **as directed**, junction boxes.

B. Flat-Top, Multichannel, Underfloor Raceways
1. Description:
a. Material: Steel.
b. Cross-Section Shape: Rectangular.
c. Number of Longitudinal Channels: Two **OR** Three **OR** Four, **as directed**, separated by steel wall(s).
d. Number of Levels: One **OR** Two, **as directed**.
e. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.

2. Service Raceways: Fitted with preset inserts.
a. Nominal Raceway Dimensions:
1) Depth: 1-3/8 inches (35 mm).
2) Power Service Channel Width: 3-1/2 inches (90 mm) **OR** 4-3/8-inches (111 mm), **as directed**.
3) Communication Service Channel Width: 3-1/2 inches (90 mm) **OR** 4 inches (102 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
b. Preset Inserts:
1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed,** o.c.
2) Size: Dimensions as required to accommodate mounting and connection of flush- and surface-mounted, single- and multiple-system service fittings or to connect to wiring extensions for feeding wall outlets for power **OR** communications **OR** power and communications, **as directed**.
3) Equip each insert with a disposable cover arranged for installation with top 1/8 inch (3 mm) below surface of concrete.
4) Arrange inserts for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to flush or surface outlet-mounting connector, jack, and receptacle devices.

3. Header Raceways: Multichannel, without preset inserts (blank raceway).
a. Nominal Raceway Dimensions:
1) Header Raceway Depth: Same as service raceways **OR** 2-1/2 inches (64 mm) **OR** 2-3/4 inches (70 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (90 mm), **as directed**.

2) Power Header Channel Width: 3-1/2 inches (90 mm) **OR** 4-3/8-inches (111 mm), **as directed**.
3) Communication Header Channel Width: 3-1/2 inches (90 mm) **OR** 4 inches (102 mm) **OR** 6-1/2 inches (165 mm), **as directed**.

b. Arrangement: In same plane as **OR** Below, **as directed**, service raceways.
c. Connections: Arranged to connect with service raceways at single-level **OR** two-level, **as directed**, junction boxes.

C. Flush, Flat-Top Underfloor Raceways
1. Description:
a. Material: Steel.
b. Cross-Section Shape: Rectangular, single channel and multichannel, separated by steel wall(s).
c. Listed and labeled for installation with top flush with concrete floor.
d. Number of Levels: One.
2. Service Raceways: Fitted with preset inserts.
a. Number of Longitudinal Channels per Multichannel Raceway: Two **OR** Three, **as directed**.
b. Number of Single-Channel Raceways per Run: One **OR** Two **OR** Three, **as directed**, unless otherwise indicated.
c. Nominal Channel Dimensions: 3 inches (76 mm) wide by 1-1/4 inches (32 mm) deep.
d. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.
1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c., full length of each service raceway.
2) Arrangement: Stagger insert locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
3) Size: 1-5/8-inch (41-mm) diameter.
3. Header Raceways: Raceways same as service raceways except without preset inserts (blank raceway).
a. Nominal Channel Dimensions: Same as service raceways.
b. Arrangement: In same plane as service raceways.
c. Connections: Arranged to connect with service raceways at junction boxes.

D. Cellular Metal Underfloor Raceways
1. Service Raceways: Fitted with preset inserts.
a. Material: Steel.
b. Number of Longitudinal Cells: Three, separated by steel walls.
c. Nominal Dimensions of Cells:
1) Overall Depth: 1-1/4 inches (32 mm) unless otherwise indicated.
2) Cross-Sectional Area of Cells: Power cells: 5-1/2 sq. in. (35.5 sq. cm); communication system cells: 16 sq. in. (103 sq. cm).
d. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.
e. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical outlet access to each cell of each raceway designated for service raceway use. Inserts shall be provided throughout the entire length of each such raceway.
1) Spacing: 30 inches (762 mm) **OR** 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed,** o.c.
2) Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-system service fitting.
3) Include mounting and connecting provisions for a surface, single- or multiple-system service fitting.

4) Include connecting provisions for a wiring-extension service fitting to feed wall outlets.
5) Equip each insert with a disposable cover plate arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable top.

2. Header Assembly: A junction box and raceway arrangement arranged to feed wires and cables to service raceways.
   a. Three-compartment junction box connecting blank, multicell cellular header raceway (no inserts) with cellular service raceways.
      1) Arrange junction box in the center of a 60-inch (152-cm) length of header raceway.
      2) Cellular header raceway shall have same dimensions as service raceways.
      3) Provide capability for service raceways to be run in both directions from intersection with header raceway.
   b. Three-compartment junction box preassembled with blank, flat-top, multichannel header raceway (no inserts) and fitted to connect with cellular service raceway at right angles to header raceway.
      1) Arrange junction box in the center of a 60-inch (152-cm) length of header raceway.
      2) Provide capability for service raceways to be run in both directions from intersection with header raceway.

E. Trench-Type Underfloor Raceways
1. Trench: Steel, shop or factory welded and fabricated to indicated sizes. Include the following features:
   a. Slab Depth Adjustment: Minimum of minus 1/8 inch (3 mm) to plus 5/8 inch (16 mm) before and during concrete placement.
   b. Cover Supports: Height adjustable, with leveling screws to rigidly support cover assembly.
   c. Screed Strip: Extruded aluminum along both edges at proper elevation without requiring shim material.
   d. Trim Strip: Select to accommodate floor finish material.
   e. Partitions: Arranged to separate channels and isolate wiring of different systems.
   f. Grommeted openings in active floor cells or service raceways.
   g. Manufacturer's standard corrosion-resistant finish, applied after fabrication.
2. Cover Plates: Removable, steel plates, 1/4 inch (6 mm) thick, each weighing 60 lb (27 kg) or less with full gasket attached to side units. Fabricate intermediate supports to limit unsupported spans to 15 inches (380 mm) or less. Fabricate covers with appropriate depth recess to receive indicated floor finish.

F. Electrical Connection Components For Cellular Steel Floor Deck
1. Preset Inserts: Rectangular metal-housing assemblies.
   a. Spacing: 30 inches (762 mm) **OR** 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed,** o.c.
   b. Size: As required to provide electrical outlet access to each cell of each group of three cells that is designated for electrical service raceway use.
   c. Equip each insert with a disposable cover arranged for installation with top 1/8 inch (3 mm) below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable cover.
   d. Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-system service fitting.
   e. Include mounting and connecting provisions for a surface, single-, double-, or triple-system service fitting.
   f. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.

G. Electrical Connection Components For Cellular Concrete Floor Deck
1. Afterset Inserts: Round metal-nipple assembly with internal and external threading, arranged to screw into plug driven into 1-7/8-inch (48-mm) hole drilled through floor fill, where present, and deck-cell wall into floor raceway cell.

a. Inserts shall be compatible with floor-mounting service fittings.
b. Inserts shall provide wiring path from cell to power **OR** communication **OR** power and communication, **as directed**, wall and ceiling outlets.
c. Inserts shall provide wiring path from cell to header raceway.

H. Supports, Fittings, And Hardware
1. Supports, fittings, and hardware shall be compatible with raceway and outlet system and shall be listed for use with raceway systems and components specified.
2. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.
3. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.

I. Junction Boxes
1. Description: Manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:
a. Mounting brackets.
b. Escutcheons and holders to accommodate surrounding floor covering.
c. Means for leveling and height adjustment more than 3/8 inch (10 mm) before and after concrete is placed.
d. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
e. Covers shall have appropriate depth recess to receive specific floor finish material.
f. Partitions to separate wiring of different systems.

J. Service Fittings
1. Exposed Parts Finish: Brass **OR** Brushed Aluminum, **as directed**.
2. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.
a. Connector, Jack, and Receptacle Devices: Single modular type; complying with Division 16 Section(s) "Wiring Devices" AND "Communications Horizontal Cabling".
b. Power Receptacle Outlet: Suitable for 20-A device.
3. Flush, Single- or Multiple-System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.
a. Connector, Jack, and Receptacle Devices: Modular type; complying with Division 16 Section(s) "Wiring Devices" AND "Communications Horizontal Cabling".
b. Power Receptacle Rating: 20 A, 120 V unless otherwise indicated.
4. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts and shall include covers; provisions for receptacles, jacks, and connectors; and associated device plates for indicated systems. Include hinged flush handhole covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies complying with requirements in Division 16 Section(s) "Wiring Devices" AND "Communications Horizontal Cabling".
a. Duplex receptacle.
b. Duplex telephone-data jacks.
c. Double duplex receptacles.
d. Duplex receptacle and duplex telephone-data jacks.
e. Double duplex telephone-data jacks, Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
f. Fiber-optic cable connector.

5. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.
   a. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
   b. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
   c. Communication-outlet, double-faced, surface-mounted unit.
      1) Include bushed openings on both sides; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
      2) Include provisions for modular dual fiber-optic connector assembly on both sides.
      3) Include provisions for modular dual jack-connector assembly, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**, on both sides.
   d. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
   e. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.
      1) Communication Side: Include bushed opening; 1-inch (25-mm) minimum diameter; insulated with nonconducting material.
      2) Communication Side: Include provisions for modular dual fiber-optic connector assembly.
      3) Communication Side: Include provisions for modular dual jack-connector assembly, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and shall include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush handhole covers, recessed to suit floor finish material. Internally mounted, modular, receptacle, jack and connector assemblies shall comply with requirements in Division 16 Section(s) "Wiring Devices" AND "Communications Horizontal Cabling".
   a. Duplex convenience receptacle.
   b. Duplex telephone-data outlets.
   c. Double duplex convenience receptacles.
   d. Duplex convenience receptacle and duplex telephone-data outlets.
   e. Double duplex telephone-data outlets.
   f. Duplex communication jack, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
   g. Duplex fiber-optic communication connector.
   h. Wiring-Extension Service Fittings: Arrangement of brackets and mountings to support, and provide access to wiring or cabling of a cell, and to connect the cable or raceway that extends the system to an individual wall outlet. Provide for connection of FMC **OR** ENT **OR** Type MC cable, **as directed**, for power extensions, and FMC **OR** ENT **OR** optical fiber/communication cable raceway, **as directed**, for communication system extensions.

1.3 EXECUTION

A. Installation
   1. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to building walls.
   2. Provide a concrete base for support of cellular metal raceway.
   3. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Install supports securely at ends and at intervals not to exceed 60 inches (1500 mm), to prevent movement during concrete pour.
   4. Level raceway components with finished slab and make adjustments for floor finishes.
   5. Adjust supports to maintain a 1/16- to 3/8-inch (1.6- to 10-mm) finished concrete cover over preset inserts.
   6. Remove burrs, sharp edges, dents, and mechanical defects.
   7. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.

8. Seal raceways, cells, junction boxes, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Tape joints, or seal with compound, as recommended in writing by underfloor raceway manufacturer.
9. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of Work.
10. Afterset Inserts: Cut, hole saw, and drill slab and raceways to allow for installation.
11. Ground underfloor raceway components.
12. Install a marker at the center of the last insert of each cell and channel of each straight run of metal underfloor service raceway to locate the insert and identify the system.
    a. Install markers at last inserts on both sides of permanent walls and at first inserts adjacent to each junction box.
    b. Install markers flush at screed line before pouring slab or placing fill. Extend marker with grommeted screw when floor covering is placed. Do not extend through carpet.
    c. Use slotted-head screw to identify electrical power; use Phillips-head screw to identify conventional communications.
    d. Use another distinctive screw head to identify third system such as special-purpose wiring.
13. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.

B. Field Quality Control
1. Perform tests and inspections.
    a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
    a. Perform visual inspection of interior of each junction box **OR** section of trench raceway, **as directed**, to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
    b. Perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.
        1) Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.
        2) Comply with NETA Acceptance Testing Specifications about safety, suitability of test equipment, test instrument calibration, and test report and records.

C. Cleaning
1. Clean and swab out underfloor raceways, inserts, and junction boxes after finish has been applied to floor slab, and remove foreign material, dirt, and moisture. Leave interiors clean and dry.

END OF SECTION 16113

Task	Specification	Specification Description
16119	01352	No Specification Required
16119	05410a	Cold-Formed Metal Framing
16119	05500	Metal Fabrications

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SECTION 16120 - COMMON WORK RESULTS FOR ELECTRICAL

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common work results for electrical. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Electrical equipment coordination and installation.
b. Sleeves for raceways and cables.
c. Sleeve seals.
d. Grout.
e. Common electrical installation requirements.

C. Definitions
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Product Data: For sleeve seals.

1.2 PRODUCTS

A. Sleeves For Raceways And Cables
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
a. Minimum Metal Thickness:
1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

B. Sleeve Seals
1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

C. Grout

1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

1.3 EXECUTION

A. Common Requirements For Electrical Installation
1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation For Electrical Penetrations
1. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
7. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

C. Sleeve-Seal Installation
1. Install to seal exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve

seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping
   1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Through-penetration Firestop Systems".

END OF SECTION 16120

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SECTION 16120a - COMMON WORK RESULTS FOR COMMUNICATIONS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common work results for communications. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Communications equipment coordination and installation.
b. Sleeves for pathways and cables.
c. Sleeve seals.
d. Grout.
e. Common communications installation requirements.

C. Definitions
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Product Data: For sleeve seals.

1.2 PRODUCTS

A. Sleeves For Pathways And Cables
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
a. Minimum Metal Thickness:
1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

B. Sleeve Seals
1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

C. Grout

1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

1.3 EXECUTION

A. Common Requirements For Communications Installation
1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation For Communications Penetrations
1. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
7. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pathway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
11. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

C. Sleeve-Seal Installation
1. Install to seal exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve

seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping

1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Through-penetration Firestop Systems".

END OF SECTION 16120a

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SECTION 16120b - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common work results for electronic safety and security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Electronic safety and security equipment coordination and installation.
b. Sleeves for raceways and cables.
c. Sleeve seals.
d. Grout.
e. Common electronic safety and security installation requirements.

C. Definitions
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Product Data: For sleeve seals.

1.2 PRODUCTS

A. Sleeves For Raceways And Cables
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
a. Minimum Metal Thickness:
1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

B. Sleeve Seals
1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

C. Grout

1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

1.3 EXECUTION

A. Common Requirements For Electronic Safety And Security Installation
1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

B. Sleeve Installation For Electronic Safety And Security Penetrations
1. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
7. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

C. Sleeve-Seal Installation
1. Install to seal exterior wall penetrations.

2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping

1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Through-penetration Firestop Systems".

END OF SECTION 16120b

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SECTION 16120c - CONDUCTORS AND CABLES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of conductors and cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Building wires and cables rated 600 V and less.
b. Connectors, splices, and terminations rated 600 V and less.
c. Sleeves and sleeve seals for cables.

C. Definitions
1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

D. Submittals
1. Product Data: For each type of product indicated.
2. Field quality-control test reports.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Conductors And Cables
1. Aluminum and Copper, **as directed**, Conductors: Comply with NEMA WC 70.
2. Conductor Insulation: Comply with NEMA WC 70 for Types THW **OR** THHN-THWN **OR** XHHW **OR** UF **OR** USE **OR** SO, **as directed**.
3. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC **OR** metal-clad cable, Type MC **OR** mineral-insulated, metal-sheathed cable, Type MI **OR** nonmetallic-sheathed cable, Type NM **OR** Type SO **OR** Type USE, **as directed**, with ground wire.

B. Connectors And Splices
1. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

C. Sleeves For Cables
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Through-penetration Firestop Systems".

D. Sleeve Seals
1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
   a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
   b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
   c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

1.3 EXECUTION

A. Conductor Material Applications
1. Feeders: Copper **OR** Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger, **as directed**. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
2. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Conductor Insulation And Multiconductor Cable Applications And Wiring Methods
1. Service Entrance: Type THHN-THWN, single conductors in raceway **OR** Type XHHW, single conductors in raceway **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Type SE or USE multiconductor cable, **as directed**.
2. Exposed Feeders: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
3. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
4. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway **OR** Underground feeder cable, Type UF, **as directed**.
5. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.
6. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
7. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
8. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
9. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway **OR** Underground branch-circuit cable, Type UF, **as directed**.
10. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.

11. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.
12. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
13. Class 1 Control Circuits: Type THHN-THWN, in raceway.
14. Class 2 Control Circuits: Type THHN-THWN, in raceway **OR** Power-limited cable, concealed in building finishes **OR** Power-limited tray cable, in cable tray, **as directed**.

C. Installation Of Conductors And Cables
1. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
2. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
4. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
5. Support cables according to Division 16 Section "Hangers And Supports For Electrical Systems".
6. Identify and color-code conductors and cables according to Division 16 Section "Electrical Identification".
7. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
8. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   a. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
9. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) **OR** 12 inches (300 mm), **as directed**, of slack.

D. Sleeve Installation For Electrical Penetrations
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Through-penetration Firestop Systems".
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
   a. For sleeve rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
   b. For sleeve rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both wall surfaces.
7. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
8. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance, **as directed**.
9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies, **as directed**.
10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants".

11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Through-penetration Firestop Systems".
12. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
13. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

E. Sleeve-Seal Installation
1. Install to seal underground exterior-wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

F. Firestopping
1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Through-penetration Firestop Systems".

G. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
   a. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services, **as directed**, for compliance with requirements.
   b. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   c. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
      1) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
      2) Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      3) Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Test Reports: Prepare a written report to record the following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
4. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 16120c

SECTION 16120d - UNDERCARPET CABLES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of undercarpet cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Undercarpet cable and service fittings for branch circuits.
b. Undercarpet cable and service fittings for communication and data transmission.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details of components, and attachments to other work.
a. Indicate cable types, accessories, and transition boxes.
b. Indicate proposed layering of cables, cable dimensions, and installation requirements.
3. Field quality-control test reports.
4. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA UC 2, "Undercarpet Power Distribution Systems" and with NFPA 70.

1.2 PRODUCTS

A. Power Distribution Cable
1. Cable: Factory laminated and complying with NEMA UC 2; three-piece assembly including bottom shield, conductor assembly, and top shield.
a. Bottom Shield: Abrasion resistant, nonmetallic **OR** Metallic, **as directed**.
b. Conductor Assembly: Two **OR** Three **OR** Four, **as directed**,-wire branch circuit with insulated ground, **as directed**.
c. Top Shield: Copper or copper alloy.
2. Current Rating: 20 **OR** 30 **OR** 20 and 30, **as directed**, A.

B. Communication And Data Cable
1. Category 5e Communication and Data Cable: Extruded-vinyl jacket over 4 unshielded, twisted pairs, No. 24 AWG, copper; complying with TIA/EIA 568-B; and tested to 300-lb (136-kg) rollover test.

C. Pedestals
1. Description: Manufacturer's standard low **OR** regular, **as directed**,-profile type, single **OR** two **OR** three, **as directed**, gang with single **OR** duplex, **as directed**, receptacles and Category 5e modular connectors, **as directed**.
a. Pedestal Colors: As selected from manufacturer's full range.

D. Power Cable Transition Unit

1. Description: Interface transition unit, with junction box, for connecting three-, four-, or five-conductor, flat-conductor cable to building wiring system.

E. Communication And Data Cable Transition Unit
1. Description: Category 5 transition termination circuit board in wall-mounted box to convert round incoming cable to outgoing flat-undercarpet cable.

1.3 EXECUTION

A. Installation
1. Do not begin installation until heavy construction is completed and wheeled traffic is no longer a threat.
2. Do not stack cables in circulation routes.
3. Limit total installed height to 0.09 inch (2.29 mm).
4. Install cables in proper order with power-transmission cable first, followed by telephone cable and then data cable. Cross cables at 90-degree angles.
5. Install undercarpet cables and accessories using special tools as recommended by undercarpet cable manufacturer.

B. Connections
1. Ground equipment according to Division 16 Section "Grounding And Bonding".
2. Connect undercarpet cable and components to branch circuits and to ground as indicated and instructed by manufacturer.

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
   a. Branch-Circuit Cables: After cables have been installed and energized, perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   b. Communication and Data Cables: After cables have been installed and connected between telecommunications outlet and system cross-connect panel, test each cable according to TIA/EIA TSB67. Certify compliance with test parameters.
3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 16120d

SECTION 16120e - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of control-voltage electrical power cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. UTP cabling.
b. 50/125 **OR** 62.5/125, **as directed**,-micrometer, multimode optical fiber cabling.
c. RS-232 cabling.
d. RS-485 cabling.
e. Low-voltage control cabling.
f. Control-circuit conductors.
g. Identification products.

C. Definitions
1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
3. EMI: Electromagnetic interference.
4. IDC: Insulation displacement connector.
5. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
6. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
7. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
8. RCDD: Registered Communications Distribution Designer.
9. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.
10. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
11. UTP: Unshielded twisted pair.

D. Submittals
1. Product Data: For each type of product indicated.
2. Field quality-control reports.
3. Maintenance data.

E. Quality Assurance
1. Testing Agency Qualifications: Member company of an NRTL.
a. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
a. Flame-Spread Index: 25 or less.
b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.

3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Delivery, Storage, And Handling
1. Test cables upon receipt at Project site.
a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight **OR** optical loss test set, **as directed**.
b. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
c. Test each pair of UTP cable for open and short circuits.

1.2 PRODUCTS

A. Pathways
1. Support of Open Cabling: NRTL labeled for support of Category 5e **OR** Category 6, **as directed**, cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
a. Support brackets with cable tie slots for fastening cable ties to brackets.
b. Lacing bars, spools, J-hooks, and D-rings.
c. Straps and other devices.
2. Cable Trays:
a. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
2) Trough or Ventilated Cable Trays: Nominally 6 inches (150 mm) wide.
3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
5) Solid-Bottom or Nonventilated Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
3. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes". Flexible metal conduit shall not be used, **as directed**.
a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards
1. Description: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".

C. UTP Cable
1. Description: 100-ohm, four-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket, **as directed**.
a. Comply with ICEA S-90-661 for mechanical properties.
b. Comply with TIA/EIA-568-B.1 for performance specifications.
c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **as directed**.
d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

1) Communications, General Purpose: Type CM or Type CMG; or Type MPP, Type CMP, Type MPR, Type CMR, Type MP, or Type MPG, **as directed**.
2) Communications, Plenum Rated: Type CMP or Type MPP, **as directed**, complying with NFPA 262.
3) Communications, Riser Rated: Type CMR; or Type MPP, Type CMP, or Type MPR, **as directed**; complying with UL 1666.
4) Communications, Limited Purpose: Type CMX; or Type MPP, Type CMP, Type MPR, Type CMR, Type MP, Type MPG, Type CM, or Type CMG, **as directed**.
5) Multipurpose: Type MP or Type MPG; or Type MPP or Type MPR, **as directed**.
6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
7) Multipurpose, Riser Rated: Type MPR or Type MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware
1. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
2. Connecting Blocks: 110 style for Category 5e **OR** 110 style for Category 6 **OR** 66 style for Category 5e, **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

E. Optical Fiber Cable
1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
   a. Comply with ICEA S-83-596 for mechanical properties.
   b. Comply with TIA/EIA-568-B.3 for performance specifications.
   c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
   d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
      1) General Purpose, Nonconductive: Type OFN or OFNG, or Type OFNR or Type OFNP, **as directed**.
      2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
      3) Riser Rated, Nonconductive: Type OFNR or Type OFNP, **as directed**, complying with UL 1666.
      4) General Purpose, Conductive: Type OFC or Type OFCG; or Type OFNG, Type OFN, Type OFCR, Type OFNR, Type OFCP, or Type OFNP, **as directed**.
      5) Plenum Rated, Conductive: Type OFCP or Type OFNP, **as directed**, complying with NFPA 262.
      6) Riser Rated, Conductive: Type OFCR; or Type OFNR, Type OFCP, or Type OFNP, **as directed**; complying with UL 1666.
   e. Conductive cable shall be steel **OR** aluminum, **as directed**,-armored type.
   f. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
   g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
   a. Jacket Color: Aqua for 50/125 **OR** Orange for 62.5/125, **as directed**,-micrometer cable.
   b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
   c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware
1. Cable Connecting Hardware: Comply with the Fiber Optic Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
   a. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
   b. Type SFF connectors may be used in termination racks, panels, and equipment packages.

G. RS-232 Cable
1. Standard Cable: NFPA 70, Type CM.
   a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   b. Polypropylene insulation.
   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   d. PVC jacket.
   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
   f. Flame Resistance: Comply with UL 1581.
2. Plenum-Rated Cable: NFPA 70, Type CMP.
   a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   b. Plastic insulation.
   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   d. Plastic jacket.
   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
   f. Flame Resistance: Comply with NFPA 262.

H. RS-485 Cable
1. Standard Cable: NFPA 70, Type CM or Type CMG, **as directed**.
   a. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1581.
2. Plenum-Rated Cable: NFPA 70, Type CMP.
   a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   b. Fluorinated ethylene propylene insulation.
   c. Unshielded.
   d. Fluorinated ethylene propylene jacket.
   e. Flame Resistance: NFPA 262, Flame Test.

I. Low-Voltage Control Cable
1. Paired Cable: NFPA 70, Type CMG.
   a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1581.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with NFPA 262.
3. Paired Cable: NFPA 70, Type CMG.
   a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1581.
4. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
   b. Fluorinated ethylene propylene insulation.
   c. Unshielded.

d. Plastic jacket.
e. Flame Resistance: NFPA 262, Flame Test.

J. Control-Circuit Conductors
1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN **OR** Type XHHN, **as directed**, in raceway, complying with UL 83 **OR** UL 44, **as directed**.
2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** Type XHHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**, complying with UL 83 **OR** UL 44, **as directed**.
3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.

K. Identification Products
1. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
2. Comply with requirements in Division 16 Section "Electrical Identification".

L. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
5. Cable will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation Of Pathways
1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
2. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
3. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
4. Install manufactured conduit sweeps and long-radius elbows if possible.
5. Pathway Installation in Equipment Rooms:
   a. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
   b. Install cable trays to route cables if conduits cannot be located in these positions.
   c. Secure conduits to backboard if entering room from overhead.
   d. Extend conduits 3 inches (75 mm) above finished floor.
   e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
6. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

B. Installation Of Conductors And Cables
1. Comply with NECA 1.
2. General Requirements for Cabling:
   a. Comply with TIA/EIA-568-B.1.
   b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

d. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

3. UTP Cable Installation:
   a. Comply with TIA/EIA-568-B.2.
   b. Install 110-style IDC termination hardware unless otherwise indicated.
   c. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
4. Installation of Control-Circuit Conductors:
   a. Install wiring in raceways. Comply with requirements specified in Division 16 Section "Raceways And Boxes".
5. Optical Fiber Cable Installation:
   a. Comply with TIA/EIA-568-B.3.
   b. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
6. Open-Cable Installation:
   a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   b. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
   c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
7. Installation of Cable Routed Exposed under Raised Floors:
   a. Install plenum-rated cable only.
   b. Install cabling after the flooring system has been installed in raised floor areas.
   c. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (305 mm) in diameter below each feed point.
8. Separation from EMI Sources:
   a. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
   b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
   c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (305 mm).
   d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

C. Removal Of Conductors And Cables

1. Remove abandoned conductors and cables.

D. Control-Circuit Conductors

1. Minimum Conductor Sizes:
   a. Class 1 remote-control and signal circuits, No 14 AWG.
   b. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
   c. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.

E. Firestopping

1. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
3. Comply with BICSI TDMM, "Firestopping Systems" Article.

F. Grounding

1. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
2. For low-voltage wiring and cabling, comply with requirements in Division 16 Section "Grounding And Bonding".

G. Identification

H. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".

I. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
   a. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
   b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   c. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.
      1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   d. Optical Fiber Cable Tests:
      1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      2) Link End-to-End Attenuation Tests:
         a) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.

b) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

3. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 16120e

SECTION 16120f - MEDIUM-VOLTAGE CABLES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of medium-voltage cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

C. Definitions
1. NETA ATS: Acceptance Testing Specification.

D. Submittals
1. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.
2. Field quality-control test reports.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2 and NFPA 70.

1.2 PRODUCTS

A. Cables
1. Cable Type: MV90 **OR** MV105, **as directed**.
2. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682, **OR** ICEA S-94-649, **as directed**.
3. Conductor: Copper **OR** Aluminum, **as directed**.
4. Conductor Stranding: Compact round, concentric lay, Class B) **OR** Concentric lay, Class B, **as directed**.
5. Strand Filling: Conductor interstices are filled with impermeable compound.
6. Conductor Insulation: Crosslinked polyethylene **OR** Ethylene-propylene rubber, **as directed**.
   a. Voltage Rating: 5 **OR** 8 **OR** 15 **OR** 25 **OR** 35, **as directed,** kV.
   b. Insulation Thickness: 100 **OR** 133, **as directed,** percent insulation level.
7. Shielding: Copper tape **OR** Solid copper wires, **as directed**, helically applied over semiconducting insulation shield.
8. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.
9. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors, **as directed**.
   a. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.
10. Cable Armor: Interlocked aluminum **OR** Interlocked galvanized steel **OR** Corrugated aluminum tube, **as directed,** applied over cable.
11. Cable Jacket: Sunlight-resistant PVC **OR** Chlorosulfonated polyethylene, CPE, **as directed**.

B. Splice Kits

1. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
2. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
   a. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
   b. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
   c. Premolded, cold-shrink-rubber, in-line splicing kit.
   d. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

C. Solid Terminations
1. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
   a. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with **OR** without, **as directed,** external plastic jacket.
   b. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
   c. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
   d. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.
2. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
   a. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
   b. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
   c. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
   d. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
   e. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
   f. Class 3 Terminations: Kit with stress cone and compression-type connector.
3. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

D. Separable Insulated Connectors
1. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
2. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
3. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

4. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
5. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
   a. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
   b. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
   c. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
   d. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
6. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
7. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

E. Arc-Proofing Materials
1. Tape for First Course on Metal Objects: 10-mil- (250-micrometer-) thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
2. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch (8 mm) thick, compatible with cable jacket.
3. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch (13 mm) wide.

F. Fault Indicators
1. Indicators: Automatically **OR** Manually, **as directed,** reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
2. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

G. Source Quality Control
1. Test and inspect cables according to ICEA S-97-682 **OR** ICEA S-94-649, **as directed,** before shipping.
2. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

1.3 EXECUTION

A. Installation
1. Install cables according to IEEE 576.
2. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
   a. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
   b. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

3. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
4. Support cables according to Division 16 Section "Common Work Results For Electrical".
5. Install direct-buried cables on leveled and tamped bed of 3-inch- (75-mm-) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4 inches (100 mm) of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
6. Install "buried-cable" warning tape 12 inches (305 mm) above cables.
7. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.
8. Install cable splices at pull points and elsewhere as indicated; use standard kits.
9. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
10. Install separable insulated-connector components as follows:
    a. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
    b. Portable Feed-Through Accessory: Three.
    c. Standoff Insulator: Three.
11. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
    a. Clean cable sheath.
    b. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
    c. Smooth surface contours with electrical insulation putty.
    d. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
    e. Band arc-proofing tape with 1-inch- (25-mm-) wide bands of half-lapped, adhesive, glass-cloth tape 2 inches (50 mm) o.c.
12. Seal around cables passing through fire-rated elements according to Division 07 Section "Through-penetration Firestop Systems".
13. Install fault indicators on each phase where indicated.
14. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
15. Identify cables according to Division 16 Section "Electrical Identification".

B. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
    a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
    b. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
2. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 16120f

SECTION 16120g - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for communications equipment room fittings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Telecommunications mounting elements.
b. Backboards.
c. Telecommunications equipment racks and cabinets.
d. Telecommunications service entrance pathways.
e. Grounding.

C. Definitions
1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. BICSI: Building Industry Consulting Service International.
3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.
4. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
5. LAN: Local area network.
6. RCDD: Registered Communications Distribution Designer.
7. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
8. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

D. Performance Requirements
1. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
c. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
3. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
4. Seismic Qualification Certificates: For floor-mounted cabinets, accessories, and components, from manufacturer.

a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Quality Assurance
1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
a. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD **OR** RCDD/NTS **OR** Commercial Installer, Level 2, **as directed**.
b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
c. Field Inspector: Currently registered by BICSI as RCDD **OR** Commercial Installer, Level 2, **as directed**, to perform the on-site inspection.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
4. Grounding: Comply with ANSI-J-STD-607-A.

G. Project Conditions
1. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

H. Coordination
1. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
a. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
b. Record agreements reached in meetings and distribute them to other participants.
c. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
d. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
2. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.2 PRODUCTS

A. Pathways
1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
a. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.

b. Support brackets with cable tie slots for fastening cable ties to brackets.
c. Lacing bars, spools, J-hooks, and D-rings.
d. Straps and other devices.

3. Cable Trays:
   a. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
      1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
      2) Trough Cable Trays: Nominally 6 inches (150 mm) wide.
      3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
      4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
      5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes". Flexible metal conduit shall not be used.
   a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry".

C. Equipment Frames
1. General Frame Requirements:
   a. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
   b. Module Dimension: Width compatible with EIA 310 standard, 19-inch (480-mm) panel mounting.
   c. Finish: Manufacturer's standard, baked-polyester powder coat.
2. Floor-Mounted Racks: Modular-type, steel **OR** aluminum, **as directed**, construction.
   a. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip, **as directed**.
   b. Baked-polyester powder coat finish.
3. Modular Freestanding Cabinets:
   a. Removable and lockable side panels.
   b. Hinged and lockable front and rear doors.
   c. Adjustable feet for leveling.
   d. Screened ventilation openings in the roof and rear door.
   e. Cable access provisions in the roof and base.
   f. Grounding bus bar.
   g. Rack **OR** Roof, **as directed**,-mounted, 550-cfm (260-L/s) fan with filter.
   h. Power strip.
   i. Baked-polyester powder coat finish.
   j. All cabinets keyed alike.
4. Modular Wall Cabinets:
   a. Wall mounting.
   b. Steel **OR** Aluminum, **as directed**, construction.
   c. Treated to resist corrosion.
   d. Lockable front and rear doors.

e. Louvered side panels.
f. Cable access provisions top and bottom.
g. Grounding lug.
h. Rack **OR** Roof, **as directed**,-mounted, 250-cfm (118-L/s) fan.
i. Power strip.
j. All cabinets keyed alike.

5. Cable Management for Equipment Frames:
   a. Metal, with integral wire retaining fingers.
   b. Baked-polyester powder coat finish.
   c. Vertical cable management panels shall have front and rear channels, with covers.
   d. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

D. Power Strips
1. Power Strips: Comply with UL 1363.
   a. Rack mounting.
   b. Six, 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R **OR** 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R, **as directed**, receptacles.
   c. LED indicator lights for power and protection status.
   d. LED indicator lights for reverse polarity and open outlet ground.
   e. Circuit Breaker and Thermal Fusing:
      1) When protection is lost, circuit opens and cannot be reset.
         OR
         Unit continues to supply power if protection is lost.
   f. Close-coupled, direct plug-in **OR** Cord connected with 15-foot (4.5-m), **as directed**, line cord.
   g. Rocker-type on-off switch, illuminated when in on position.
   h. Peak Single-Impulse Surge Current Rating: 33 **OR** 26 **OR** 13, **as directed**, kA per phase.
   i. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

E. Grounding
1. Comply with requirements in Division 16 Section "Grounding And Bonding" for grounding conductors and connectors.
2. Telecommunications Main Bus Bar:
   a. Connectors: Mechanical type, cast silicon bronze, solderless compression **OR** exothermic, **as directed**,-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
   b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
   c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
3. Comply with ANSI-J-STD-607-A.

F. Labeling
1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

1.3 EXECUTION

A. Entrance Facilities
1. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
2. Install underground **OR** buried **OR** aerial, **as directed**, pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.

a. Install underground **OR** buried, **as directed**, entrance pathway complying with Division 16 Section "Raceways And Boxes".

B. Installation
1. Comply with NECA 1.
2. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
3. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
4. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

C. Firestopping
1. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
3. Comply with BICSI TDMM, "Firestopping Systems" Article.

D. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
2. Comply with ANSI-J-STD-607-A.
3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
   a. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

E. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 16 Section "Electrical Identification".
2. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
3. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration including optional identification requirements of this standard, **as directed**.
4. Labels shall be preprinted or computer-printed type.

END OF SECTION 16120g

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SECTION 16120h - COMMUNICATIONS BACKBONE CABLING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for communications backbone cabling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Pathways.
b. UTP cable.
c. 50/125 and 62.5/125-micrometer, optical fiber cabling.
d. Coaxial cable.
e. Cable connecting hardware, patch panels, and cross-connects.
f. Cabling identification products.

C. Definitions
1. BICSI: Building Industry Consulting Service International.
2. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
3. EMI: Electromagnetic interference.
4. IDC: Insulation displacement connector.
5. LAN: Local area network.
6. RCDD: Registered Communications Distribution Designer.
7. UTP: Unshielded twisted pair.

D. Backbone Cabling Description
1. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
2. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

E. Performance Requirements
1. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

F. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings:
a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
c. Cabling administration drawings and printouts.
d. Wiring diagrams to show typical wiring schematics including the following:
1) Cross-connects.
2) Patch panels.
3) Patch cords.

e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
f. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements.

3. Qualification Data: For Installer, **as directed**, qualified layout technician, installation supervisor, and field inspector.
4. Source quality-control reports.
5. Field quality-control reports.
6. Maintenance Data.
7. Software and Firmware Operational Documentation:
   a. Software operating and upgrade manuals.
   b. Program Software Backup: On magnetic media or compact disk, complete with data files.
   c. Device address list.
   d. Printout of software application and graphic screens.

G. Quality Assurance
1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   a. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
   b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   a. Flame-Spread Index: 25 or less.
   b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
5. Grounding: Comply with ANSI-J-STD-607-A.

H. Delivery, Storage, And Handling
1. Test cables upon receipt at Project site.
   a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
   b. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
   c. Test each pair of UTP cable for open and short circuits.

I. Software Service Agreement
1. Technical Support: Beginning with Substantial Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   a. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   a. Support brackets with cable tie slots for fastening cable ties to brackets.
   b. Lacing bars, spools, J-hooks, and D-rings.
   c. Straps and other devices.
3. Cable Trays:
   a. Cable Tray Material: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inches (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inches (0.055 mm) thick, **as directed**.
      1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
      2) Trough Cable Trays: Nominally 6 inches (150 mm) wide.
      3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
      4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
      5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes". Flexible metal conduit shall not be used.
   a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

C. UTP Cable
1. Description: 100-ohm, 100-pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.
   a. Comply with ICEA S-90-661 for mechanical properties.
   b. Comply with TIA/EIA-568-B.1 for performance specifications.
   c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
   d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      1) Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
      2) Communications, Plenum Rated: Type CMP or MPP, **as directed**, complying with NFPA 262.
      3) Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, **as directed**, complying with UL 1666.
      4) Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
      5) Multipurpose: Type MP or MPG; or MPP or MPR, **as directed**.
      6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
      7) Multipurpose, Riser Rated: Type MPR or MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware
1. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

2. Connecting Blocks: 110-style IDC for Category 5e **OR** 110-style IDC for Category 6 **OR** 66-style IDC for Category 5e, **OR** 110-style IDC for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
   a. Number of Terminals per Field: One for each conductor in assigned cables.
4. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   a. Number of Jacks per Field: One for each four-pair UTP cable indicated **OR** conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria, **as directed**.
5. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
6. Patch Cords: Factory-made, 4-pair cables in 36-inch (900-mm) **OR** 48-inch (1200-mm), **as directed**, lengths; terminated with 8-position modular plug at each end.
   a. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
   b. Patch cords shall have color-coded boots for circuit identification.

E. Optical Fiber Cable
1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
   a. Comply with ICEA S-83-596 for mechanical properties.
   b. Comply with TIA/EIA-568-B.3 for performance specifications.
   c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
   d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
      1) General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP, **as directed**.
      2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
      3) Riser Rated, Nonconductive: Type OFNR or OFNP, **as directed**, complying with UL 1666.
      4) General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
      5) Plenum Rated, Conductive: Type OFCP or OFNP, **as directed**, complying with NFPA 262.
      6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **as directed**, complying with UL 1666.
   e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
   f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
   g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
   a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
   b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
   c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware
1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
   a. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

2. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
3. Cable Connecting Hardware:
   a. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
   b. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
   c. Type SFF connectors may be used in termination racks, panels, and equipment packages.

G. Coaxial Cable
1. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
2. RG-11/U: NFPA 70, Type CATV.
   a. No. 14 AWG, solid, copper-covered steel conductor.
   b. Gas-injected, foam-PE insulation.
   c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
   d. Jacketed with sunlight-resistant, black PVC or PE.
   e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
3. RG59/U: NFPA 70, Type CATVR.
   a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
   b. Gas-injected, foam-PE insulation.
   c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
   d. Color-coded PVC jacket.
4. RG-6/U: NFPA 70, Type CATV or CM.
   a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
   b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
   c. Jacketed with black PVC or PE.
   d. Suitable for indoor installations.
5. RG59/U: NFPA 70, Type CATV.
   a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
   b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
   c. PVC jacket.
6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
   a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
   b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
   c. Copolymer jacket.
7. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
   a. CATV Cable: Type CATV, or CATVP or CATVR, **as directed**.
   b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
   c. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
   d. CATV Limited Rating: Type CATVX.

H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.

I. Grounding
1. Comply with requirements in Division 16 Section "Grounding And Bonding" for grounding conductors and connectors.
2. Comply with ANSI-J-STD-607-A.

J. Identification Products
1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

K. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
5. Cable will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

1.3 EXECUTION

A. Entrance Facilities
1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

B. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways And Boxes".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

C. Installation Of Pathways
1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.
2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 16 Section "Communications Equipment Room Fittings". Drawings indicate general arrangement of pathways and fittings.
3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
4. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
5. Install manufactured conduit sweeps and long-radius elbows whenever possible.
6. Pathway Installation in Communications Equipment Rooms:
   a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   b. Install cable trays to route cables if conduits cannot be located in these positions.
   c. Secure conduits to backboard when entering room from overhead.
   d. Extend conduits 3 inches (76 mm) above finished floor.
   e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
7. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

D. Installation Of Cables
   1. Comply with NECA 1.
   2. General Requirements for Cabling:
      a. Comply with TIA/EIA-568-B.1.
      b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
      c. Install 110-style IDC termination hardware unless otherwise indicated.
      d. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
      e. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
      f. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
      g. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
      h. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
      i. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
      j. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
      k. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
   3. UTP Cable Installation:
      a. Comply with TIA/EIA-568-B.2.
      b. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
   4. Optical Fiber Cable Installation:
      a. Comply with TIA/EIA-568-B.3.
      b. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
   5. Open-Cable Installation:
      a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
      b. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
      c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
   6. Installation of Cable Routed Exposed under Raised Floors:
      a. Install plenum-rated cable only.
      b. Install cabling after the flooring system has been installed in raised floor areas.
      c. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
   7. Outdoor Coaxial Cable Installation:
      a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
      b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
   8. Group connecting hardware for cables into separate logical fields.
   9. Separation from EMI Sources:
      a. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
      b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

E. Firestopping
1. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
3. Comply with BICSI TDMM, "Firestopping Systems" Article.

F. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
2. Comply with ANSI-J-STD-607-A.
3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

G. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".
a. Administration Class: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
b. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
2. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
3. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration including optional identification requirements of this standard.
4. Comply with requirements in Division 16 Section "Communications Horizontal Cabling" for cable and asset management software.
5. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

6. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
7. Cable and Wire Identification:
   a. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   b. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
   c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
   d. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
      1) Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
      2) Label each unit and field within distribution racks and frames.
   e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:
   a. Cables use flexible vinyl or polyester that flexes as cables are bent.

H. Field Quality Control
1. Tests and Inspections:
   a. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
   b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   c. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
      1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   d. Optical Fiber Cable Tests:
      1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      2) Link End-to-End Attenuation Tests:
         a) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
         b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

2. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
3. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 16120h

SECTION 16120i - COMMUNICATIONS HORIZONTAL CABLING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for communications horizontal cabling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Pathways.
b. UTP cabling.
c. 50/125 and 62.5/125-micrometer, optical fiber cabling.
d. Coaxial cable.
e. Multiuser telecommunications outlet assemblies.
f. Cable connecting hardware, patch panels, and cross-connects.
g. Telecommunications outlet/connectors.
h. Cabling system identification products.
i. Cable management system.

C. Definitions
1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. BICSI: Building Industry Consulting Service International.
3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel.
4. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
5. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
6. EMI: Electromagnetic interference.
7. IDC: Insulation displacement connector.
8. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
9. LAN: Local area network.
10. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
11. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
12. RCDD: Registered Communications Distribution Designer.
13. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom without ventilation openings.
14. Trough or Ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom having openings for the passage of air.
15. UTP: Unshielded twisted pair.

D. Horizontal Cabling Description
1. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.
a. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.

b. Horizontal cabling shall contain no more that one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
c. Bridged taps and splices shall not be installed in the horizontal cabling.
d. Splitters shall not be installed as part of the optical fiber cabling.

2. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
3. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.

E. Performance Requirements
1. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

F. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings:
a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
c. Cabling administration drawings and printouts.
d. Wiring diagrams to show typical wiring schematics, including the following:
1) Cross-connects.
2) Patch panels.
3) Patch cords.
e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
f. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements.
3. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration and faceplates for color selection and evaluation of technical features.
4. Qualification Data: For Installer, **as directed**, qualified layout technician, installation supervisor, and field inspector.
5. Source quality-control reports.
6. Field quality-control reports.
7. Maintenance Data.
8. Software and Firmware Operational Documentation:
a. Software operating and upgrade manuals.
b. Program Software Backup: On magnetic media or compact disk, complete with data files.
c. Device address list.
d. Printout of software application and graphic screens.

G. Quality Assurance
1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
a. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
a. Flame-Spread Index: 25 or less.

b. Smoke-Developed Index: 50 **OR** 450, **as directions**, or less.

3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
5. Grounding: Comply with ANSI-J-STD-607-A.

H. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
   a. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
   b. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
   c. Test each pair of UTP cable for open and short circuits.

I. Software Service Agreement

1. Technical Support: Beginning with Substantial Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   a. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   a. Support brackets with cable tie slots for fastening cable ties to brackets.
   b. Lacing bars, spools, J-hooks, and D-rings.
   c. Straps and other devices.
3. Cable Trays:
   a. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
      1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
      2) Trough Cable Trays: Nominally 6 inches (150 mm) wide.
      3) Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).
      4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm) wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
      5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm) wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes". Flexible metal conduit shall not be used.
   a. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards

1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

C. UTP Cable
1. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
   a. Comply with ICEA S-90-661 for mechanical properties.
   b. Comply with TIA/EIA-568-B.1 for performance specifications.
   c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
   d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      1) Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
      2) Communications, Plenum Rated: Type CMP or MPP, **as directed**, complying with NFPA 262.
      3) Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, **as directed**, complying with UL 1666.
      4) Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
      5) Multipurpose: Type MP or MPG; or MPP or MPR, **as directed**.
      6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
      7) Multipurpose, Riser Rated: Type MPR or MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware
1. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
2. Connecting Blocks: 110-style IDC for Category 5e **OR** 110-style IDC for Category 6 **OR** 66-style IDC for Category 5e, OR 110-style IDC for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
   a. Number of Terminals per Field: One for each conductor in assigned cables.
4. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   a. Number of Jacks per Field: One for each four-pair UTP cable indicated **OR** conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria, **as directed**.
5. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
6. Patch Cords: Factory-made, four-pair cables in 36-inch (900 mm) **OR** 48-inch (1200-mm), **as directed**, lengths; terminated with eight-position modular plug at each end.
   a. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
   b. Patch cords shall have color-coded boots for circuit identification.

E. Optical Fiber Cable
1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
   a. Comply with ICEA S-83-596 for mechanical properties.
   b. Comply with TIA/EIA-568-B.3 for performance specifications.

c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
1) General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP, **as directed**.
2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
3) Riser Rated, Nonconductive: Type OFNR or OFNP, **as directed**, complying with UL 1666.
4) General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
5) Plenum Rated, Conductive: Type OFCP or OFNP, **as directed**, complying with NFPA 262.
6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **as directed**, complying with UL 1666.
e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

2. Jacket:
a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware
1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
a. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
2. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
3. Cable Connecting Hardware:
a. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
b. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
c. Type SFF connectors may be used in termination racks, panels, and equipment packages.

G. Coaxial Cable
1. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
2. RG-11/U: NFPA 70, Type CATV.
a. No. 14 AWG, solid, copper-covered steel conductor.
b. Gas-injected, foam-PE insulation.
c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
d. Jacketed with sunlight-resistant, black PVC or PE.
e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
3. RG59/U: NFPA 70, Type CATVR.
a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
b. Gas-injected, foam-PE insulation.
c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
d. Color-coded PVC jacket.
4. RG-6/U: NFPA 70, Type CATV or CM.

a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
c. Jacketed with black PVC or PE.
d. Suitable for indoor installations.

5. RG59/U: NFPA 70, Type CATV.
   a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
   b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
   c. PVC jacket.
6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
   a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
   b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
   c. Copolymer jacket.
7. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
   a. CATV Cable: Type CATV or CATVP or CATVR, **as directed**.
   b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
   c. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
   d. CATV Limited Rating: Type CATVX.

H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.

I. Consolidation Points
1. Description: Consolidation points shall comply with requirements for cable connecting hardware.
   a. Number of Terminals per Field: One for each conductor in assigned cables.
   b. Number of Connectors per Field:
      1) One for each four-pair UTP cable indicated.
      2) One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
   c. Mounting: Recessed in ceiling **OR** Wall **OR** Desk **OR** Furniture, **as directed**.
   d. NRTL listed as complying with UL 50 and UL 1863.
   e. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

J. Multiuser Telecommunications Outlet Assembly (MUTOA)
1. Description: MUTOAs shall meet the requirements for cable connecting hardware.
   a. Number of Terminals per Field: One for each conductor in assigned cables.
   b. Number of Connectors per Field:
      1) One for each four-pair UTP cable indicated.
      2) One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
   c. Mounting: Recessed in ceiling **OR** Wall **OR** Desk **OR** Furniture, **as directed**.
   d. NRTL listed as complying with UL 50 and UL 1863.
   e. Label shall include maximum length of work area cords, based on TIA/EIA-568-B.1.
   f. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

K. Telecommunications Outlet/Connectors
1. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
2. Workstation Outlets: Two **OR** Four, **as directed**,-port-connector assemblies mounted in single or multigang faceplate.

a. Plastic Faceplate: High-impact plastic. Coordinate color with Division 16 Section "Wiring Devices".
b. Metal Faceplate: Stainless steel **OR** Brass, **as directed**, complying with requirements in Division 16 Section "Wiring Devices".
c. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
   1) Flush mounting jacks, positioning the cord at a 45-degree angle.
d. Legend:
   1) Factory labeled by silk-screening or engraving for stainless steel **OR** brass, **as directed**, faceplates.
      OR
      Machine printed, in the field, using adhesive-tape label.
      OR
      Snap-in, clear-label covers and machine-printed paper inserts.

L. Grounding
1. Comply with requirements in Division 16 Section "Grounding And Bonding" for grounding conductors and connectors.
2. Comply with ANSI-J-STD-607-A.

M. Identification Products
1. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
2. Comply with requirements in Division 16 Section "Electrical Identification".

N. Cable Management System
1. Description: Computer-based cable management system, with integrated database and graphic, **as directed**, capabilities.
2. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.
3. Information shall be presented in database view, schematic plans, or technical drawings.
   a. Microsoft Visio Professional or AutoCAD drawing software shall be used as drawing and schematic plans software.
4. System shall interface with the following testing and recording devices:
   a. Direct upload tests from circuit testing instrument into the personal computer.
   b. Direct download circuit labeling into labeling printer.

O. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
5. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Prepare test and inspection reports.

1.3 EXECUTION

A. Entrance Facilities
1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

B. Wiring Methods

1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways And Boxes".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

C. Installation Of Pathways
1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 16 Section "Communications Equipment Room Fittings". Drawings indicate general arrangement of pathways and fittings.
3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
4. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
5. Install manufactured conduit sweeps and long-radius elbows whenever possible.
6. Pathway Installation in Communications Equipment Rooms:
   a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   b. Install cable trays to route cables if conduits cannot be located in these positions.
   c. Secure conduits to backboard when entering room from overhead.
   d. Extend conduits 3 inches (76 mm) above finished floor.
   e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
7. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

D. Installation Of Cables
1. Comply with NECA 1.
2. General Requirements for Cabling:
   a. Comply with TIA/EIA-568-B.1.
   b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   c. Install 110-style IDC termination hardware unless otherwise indicated.
   d. MUTOA shall not be used as a cross-connect point.
   e. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
      1) Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      2) Locate consolidation points for UTP at least 49 feet (15 m) from communications equipment room.
   f. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   g. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   h. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

i. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
j. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
k. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
l. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
m. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

3. UTP Cable Installation:
   a. Comply with TIA/EIA-568-B.2.
   b. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
4. Optical Fiber Cable Installation:
   a. Comply with TIA/EIA-568-B.3.
   b. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
5. Open-Cable Installation:
   a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   b. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
   c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
6. Installation of Cable Routed Exposed under Raised Floors:
   a. Install plenum-rated cable only.
   b. Install cabling after the flooring system has been installed in raised floor areas.
   c. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
7. Outdoor Coaxial Cable Installation:
   a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
   b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
8. Group connecting hardware for cables into separate logical fields.
9. Separation from EMI Sources:
   a. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
   b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
   c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
   d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).

f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

E. Firestopping

1. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
3. Comply with BICSI TDMM, "Firestopping Systems" Article.

F. Grounding

1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
2. Comply with ANSI-J-STD-607-A.
3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

G. Identification

1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".
   a. Administration Class: 1 **OR** 2 **OR** 3 **OR** 4, **as directed**.
   b. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
2. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
3. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
4. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration, including optional identification requirements of this standard.
5. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
6. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
7. Cable and Wire Identification:
   a. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.

b. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
d. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
1) Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
2) Label each unit and field within distribution racks and frames.
e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
f. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.
8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
a. Cables use flexible vinyl or polyester that flex as cables are bent.

H. Field Quality Control
1. Tests and Inspections:
a. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
b. Visually confirm Category 5e **OR** Category 6, **OR** Category 6e **as directed**, marking of outlets, cover plates, outlet/connectors, and patch panels.
c. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
d. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
e. Optical Fiber Cable Tests:
1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
2) Link End-to-End Attenuation Tests:
a) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
f. UTP Performance Tests:
1) Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
a) Wire map.
b) Length (physical vs. electrical, and length requirements).
c) Insertion loss.

d) Near-end crosstalk (NEXT) loss.
e) Power sum near-end crosstalk (PSNEXT) loss.
f) Equal-level far-end crosstalk (ELFEXT).
g) Power sum equal-level far-end crosstalk (PSELFEXT).
h) Return loss.
i) Propagation delay.
j) Delay skew.

g. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.3.

h. Coaxial Cable Tests: Conduct tests according to Division 16 Section "Master Antenna Television System".

i. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.

1) Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

2) Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

2. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

3. End-to-end cabling will be considered defective if it does not pass tests and inspections.

4. Prepare test and inspection reports.

END OF SECTION 16120i

SECTION 16120j - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for conductors and cables for electronic safety and security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. UTP cabling.
b. 50/125 and 62.5/125-micrometer, multimode optical fiber cabling.
c. Coaxial cabling.
d. RS-232 cabling.
e. RS-485 cabling.
f. Low-voltage control cabling.
g. Control-circuit conductors.
h. Fire alarm wire and cable.
i. Identification products.

C. Definitions
1. BICSI: Building Industry Consulting Service International.
2. EMI: Electromagnetic interference.
3. IDC: Insulation displacement connector.
4. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
5. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
6. RCDD: Registered Communications Distribution Designer.

D. Performance Requirements
1. Seismic Performance: Pathways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated.
a. For coaxial cable, include the following installation data for each type used:
1) Nominal OD.
2) Minimum bending radius.
3) Maximum pulling tension.
2. Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
a. Vertical and horizontal offsets and transitions.
b. Clearances for access above and to side of cable trays.
c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
3. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
4. Seismic Qualification Certificates: For pathways, accessories, and components, from manufacturer.

a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and Maintenance Data: For wire and cable to include in operation and maintenance manuals. Include the following:
   a. Allowable pulling tension of cable.
   b. Cable connectors and terminations recommended by the manufacturer.

F. Quality Assurance
1. Testing Agency Qualifications: An NRTL.
   a. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   a. Flame-Spread Index: 25 or less.
   b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Delivery, Storage, And Handling
1. Test cables upon receipt at Project site.
   a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
   b. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
   c. Test each pair of UTP cable for open and short circuits.

H. Project Conditions
1. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
   a. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
2. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.2 PRODUCTS

A. Pathways
1. Support of Open Cabling: NRTL labeled for support of Category 5e **OR** Category 6, **OR** Category 6e **as directed**, cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   a. Support brackets with cable tie slots for fastening cable ties to brackets.
   b. Lacing bars, spools, J-hooks, and D-rings.
   c. Straps and other devices.
2. Cable Trays:

a. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M Grade 0.55, not less than 0.002165 inch (0.055 mm) thick, **as directed**.
   1) Basket Cable Trays: 6 inches (150 mm) wide and 2 inches (50 mm) deep, **as directed**. Wire mesh spacing shall not exceed 2 by 4 inches (50 by 100 mm).
   2) Trough Cable Trays: Nominally 6 inches (150 mm), **as directed**, wide.
   3) Ladder Cable Trays: Nominally 18 inches (455 mm), **as directed**, wide, and a rung spacing of 12 inches (305 mm), **as directed**.
   4) Channel Cable Trays: One-piece construction, nominally 4 inches (100 mm), **as directed**, wide. Slot spacing shall not exceed 4-1/2 inches (115 mm) o.c.
   5) Solid-Bottom Cable Trays: One-piece construction, nominally 12 inches (305 mm), **as directed**, wide. Provide with **OR** without, **as directed**, solid covers.

3. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways and Boxes." Flexible metal conduit shall not be used, **as directed**.
4. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".

C. UTP Cable
1. Description: 100-ohm, 4-pair UTP, covered with a blue thermoplastic jacket.
   a. Comply with ICEA S-90-661 for mechanical properties.
   b. Comply with TIA/EIA-568-B.1 for performance specifications.
   c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
   d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      1) Communications, General Purpose: Type CM or CMG; **OR** MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
      2) Communications, Plenum Rated: Type CMP **OR** MPP, **as directed**, complying with NFPA 262.
      3) Communications, Riser Rated: Type CMR; **OR** MPP, CMP, or MPR, **as directed**, complying with UL 1666.
      4) Communications, Limited Purpose: Type CMX; **OR** MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
      5) Multipurpose: Type MP or MPG; **OR** MPP or MPR, **as directed**.
      6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
      7) Multipurpose, Riser Rated: Type MPR **OR** MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware
1. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
2. Connecting Blocks: 110-style for Category 5e **OR** 110-style for Category 6 **OR** 66-style for Category 5e, **OR** 110-style for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25, **as directed**, percent spare. Integral with connector bodies, including plugs and jacks where indicated.

E. Optical Fiber Cable
1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, **as directed**, nonconductive, **as directed**, tight buffer, optical fiber cable.

a. Comply with ICEA S-83-596 for indoor cable OR ICEA S-87-640 for outside plant, as directed, for mechanical properties.
b. Comply with TIA/EIA-568-B.3 for performance specifications.
c. Comply with TIA-492AAAB **OR** TIA-492AAAA-A, **as directed**, for detailed specifications.
d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   1) General Purpose, Nonconductive: Type OFN or OFNG, **OR** OFNR, OFNP, **as directed**.
   2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
   3) Riser Rated, Nonconductive: Type OFNR or OFNP, complying with UL 1666.
   4) General Purpose, Conductive: Type OFC or OFCG; **OR** OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
   5) Plenum Rated, Conductive: Type OFCP or OFNP, complying with NFPA 262.
   6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **asa directed**, complying with UL 1666.
e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

2. Jacket:
   a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
   b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
   c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware
1. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
   a. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
   b. Type SFF connectors may be used in termination racks, panels, and equipment packages.

G. Coaxial Cable
1. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
2. RG-11/U: NFPA 70, Type CATV.
   a. No. 14 AWG, solid, copper-covered steel conductor.
   b. Gas-injected, foam-PE insulation.
   c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
   d. Jacketed with sunlight-resistant, black PVC or PE.
   e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
3. RG59/U: NFPA 70, Type CATVR.
   a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
   b. Gas-injected, foam-PE insulation.
   c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
   d. Color-coded PVC jacket.
4. RG-6/U: NFPA 70, Type CATV or CM.
   a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
   b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
   c. Jacketed with black PVC or PE.

d. Suitable for indoor installations.

5. RG59/U: NFPA 70, Type CATV.
   a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
   b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
   c. PVC jacket.
6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
   a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
   b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
   c. Copolymer jacket.
7. NFPA and UL Compliance: Coaxial cables shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655, and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
   a. CATV Cable: Type CATV, **OR** CATVP or CATVR, **as directed**.
   b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
   c. CATV Riser Rated: Type CATVR; **OR** CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
   d. CATV Limited Rating: Type CATVX.

H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.

I. RS-232 Cable
1. Standard Cable: NFPA 70, Type CM.
   a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. Polypropylene insulation.
   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   d. PVC jacket.
   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   f. Flame Resistance: Comply with UL 1581.
2. Plenum-Rated Cable: NFPA 70, Type CMP.
   a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. Plastic insulation.
   c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   d. Plastic jacket.
   e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   f. Flame Resistance: Comply with NFPA 262.

J. RS-485 Cable
1. Standard Cable: NFPA 70, Type CM **OR** CMG, **as directed**.
   a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1581.
2. Plenum-Rated Cable: NFPA 70, Type CMP.
   a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
   b. Fluorinated ethylene propylene insulation.
   c. Unshielded.
   d. Fluorinated ethylene propylene jacket.
   e. Flame Resistance: NFPA 262, Flame Test.

K. Low-Voltage Control Cable

1. Paired Cable: NFPA 70, Type CMG.
   a. 1 pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with UL 1581.
2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   a. 1 pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
   b. PVC insulation.
   c. Unshielded.
   d. PVC jacket.
   e. Flame Resistance: Comply with NFPA 262.

L. Control-Circuit Conductors
1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway **OR** Type XHHN, complying with UL 44, in raceway, **as directed**.
2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway **OR** power-limited cable, complying with UL 83, concealed in building finishes **OR** power-limited tray cable, complying with UL 83, in cable tray **OR** Type XHHN, complying with UL 44, in raceway, **as directed**.
3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

M. Fire Alarm Wire And Cable
1. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
2. Signaling Line Circuits: Twisted, shielded pair, not less than **OR** No. 18 AWG **OR** size as recommended by system manufacturer, **as directed**.
   a. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
3. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
   a. Low-Voltage Circuits: No. 16 AWG, minimum.
   b. Line-Voltage Circuits: No. 12 AWG, minimum.
   c. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket, **as directed**, with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

N. Identification Products
1. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
2. Comply with requirements in Division 16 Section "Electrical Identification".

O. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.

5. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation Of Pathways
1. Cable Trays: Comply with NEMA VE 2 and TIA-569-B.
2. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
3. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
4. Install manufactured conduit sweeps and long-radius elbows whenever possible.
5. Pathway Installation in Equipment Rooms:
   a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   b. Install cable trays to route cables if conduits cannot be located in these positions.
   c. Secure conduits to backboard when entering room from overhead.
   d. Extend conduits 3 inches (75 mm) above finished floor.
   e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
6. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

B. Installation Of Hangers And Supports
1. Comply with requirements in Division 16 Section "Hangers And Supports For Electrical Systems" for installation of supports for pathways, conductors and cables.

C. Wiring Method
1. Install wiring in metal raceways and wireways. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 3/4 inch (21 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
2. Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 3/4 inch (21 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
3. Install cable, concealed in accessible ceilings, walls, and floors when possible.
4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Installation Of Conductors And Cables
1. Comply with NECA 1.
2. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
3. General Requirements for Cabling:
   a. Comply with TIA/EIA-568-B.1.
   b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
d. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

4. UTP Cable Installation: Install using techniques, practices, and methods that are consistent with Category 5e **OR** Category 6, **OR** Category 6e **as directed**, rating of components and that ensure Category 5e **OR** Category 6, **OR** Category 6e **as directed**, performance of completed and linked signal paths, end to end.
   a. Comply with TIA/EIA-568-B.2.
   b. Install 110-style IDC termination hardware unless otherwise indicated.
   c. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Optical Fiber Cable Installation:
   a. Comply with TIA/EIA-568-B.3.
   b. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
6. Outdoor Coaxial Cable Installation:
   a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
   b. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).
7. Open-Cable Installation:
   a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
   b. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
   c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
8. Installation of Cable Routed Exposed under Raised Floors:
   a. Install plenum-rated cable only.
   b. Install cabling after the flooring system has been installed in raised floor areas.
   c. Coil cable 72 inches (1830 mm) long shall be neatly coiled not less than 12 inches (300 mm) in diameter below each feed point.
9. Separation from EMI Sources:
   a. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
   b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
      1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
      2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
      3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
   2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
   3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

E. Fire Alarm Wiring Installation
1. Comply with NECA 1 and NFPA 72.
2. Wiring Method: Install wiring in metal raceway according to Division 16 Section "Raceways And Boxes".
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
3. Wiring Method:
   a. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
   b. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is **OR** is not, **as directed**, permitted.
   c. Signaling Line Circuits: Power-limited fire alarm cables may **OR** shall not, **as directed**, be installed in the same cable or raceway as signaling line circuits.
4. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
5. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
6. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
7. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
8. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

F. Power And Control-Circuit Conductors
1. 120-V Power Wiring: Install according to Division 16 Section "Conductors And Cables" unless otherwise indicated.
2. Minimum Conductor Sizes:
   a. Class 1 remote-control and signal circuits, No. 14 AWG.

b. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
c. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

G. Connections
1. Comply with requirements in Division 13 Section "Perimeter Security" for connecting, terminating, and identifying wires and cables.
2. Comply with requirements in Division 13 Section "Intrusion Detection" for connecting, terminating, and identifying wires and cables.
3. Comply with requirements in Division 13 Section "Security Access" for connecting, terminating, and identifying wires and cables.
4. Comply with requirements in Division 13 Section "Video Surveillance" for connecting, terminating, and identifying wires and cables.
5. Comply with requirements in Division 13 Section "Plc Electronic Detention Monitoring And Control Systems" for connecting, terminating, and identifying wires and cables.
6. Comply with requirements in Division 13 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed**, for connecting, terminating, and identifying wires and cables.
7. Comply with requirements in Division 15 Section "Refrigerant Detection And Alarm" for connecting, terminating, and identifying wires and cables.

H. Firestopping
1. Comply with requirements in Division 07 Section "Through-penetration Firestop Systems".
2. Comply with TIA-569-B, "Firestopping" Annex A.
3. Comply with BICSI TDMM, "Firestopping Systems" Article.

I. Grounding
1. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
2. For low-voltage wiring and cabling, comply with requirements in Division 16 Section "Grounding And Bonding".

J. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".

K. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
   b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
   c. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
      1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   d. Optical Fiber Cable Tests:

1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
2) Link End-to-End Attenuation Tests:
   a) Multimode Link Measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
   b) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

e. Coaxial Cable Tests: Comply with requirements in Division 16 Section "Master Antenna Television System".

3. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 16120j

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Task	Specification	Specification Description
16121	16120c	Conductors And Cables
16121	16120d	Undercarpet Cables
16121	16120f	Medium-Voltage Cables
16122	16120c	Conductors And Cables

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SECTION 16130 - RACEWAYS AND BOXES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of raceways and boxes. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

C. Definitions
1. EMT: Electrical metallic tubing.
2. ENT: Electrical nonmetallic tubing.
3. EPDM: Ethylene-propylene-diene terpolymer rubber.
4. FMC: Flexible metal conduit.
5. IMC: Intermediate metal conduit.
6. LFMC: Liquidtight flexible metal conduit.
7. LFNC: Liquidtight flexible nonmetallic conduit.
8. NBR: Acrylonitrile-butadiene rubber.
9. RNC: Rigid nonmetallic conduit.

D. Submittals
1. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
2. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
   a. Custom enclosures and cabinets.
   b. For handholes and boxes for underground wiring, including the following:
      1) Duct entry provisions, including locations and duct sizes.
      2) Frame and cover design.
      3) Grounding details.
      4) Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
      5) Joint details.
3. Samples: For each type of exposed finish required for wireways, nonmetallic wireways and surface raceways, prepared on Samples of size indicated below.
4. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
   a. Structural members in the paths of conduit groups with common supports.
   b. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
5. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 16 Section(s) "Hangers And Supports For Electrical Systems" AND "Vibration And Seismic Controls For Electrical Systems". Include the following:
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      1) The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

6. Qualification Data: For professional engineer and testing agency.
7. Source quality-control test reports.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Metal Conduit And Tubing
1. Rigid Steel Conduit: ANSI C80.1.
2. Aluminum Rigid Conduit: ANSI C80.5.
3. IMC: ANSI C80.6.
4. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit **OR** IMC, **as directed**.
a. Comply with NEMA RN 1.
b. Coating Thickness: 0.040 inch (1 mm), minimum.
5. EMT: ANSI C80.3.
6. FMC: Zinc-coated steel **OR** Aluminum **OR** Zinc-coated steel or aluminum, **as directed**.
7. LFMC: Flexible steel conduit with PVC jacket.
8. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
b. Fittings for EMT: Steel **OR** Die-cast, **as directed**, set-screw **OR** compression, **as directed**, type.
c. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
9. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

B. Nonmetallic Conduit And Tubing
1. ENT: NEMA TC 13.
2. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
3. LFNC: UL 1660.
4. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
5. Fittings for LFNC: UL 514B.

C. Optical Fiber/Communications Cable Raceway And Fittings
1. Description: Comply with UL 2024; flexible type, approved for plenum **OR** riser **OR** general-use, **as directed**, installation.

D. Metal Wireways
1. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 **OR** 12 **OR** 3R, **as directed**, unless otherwise indicated.
2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

3. Wireway Covers: Hinged type **OR** Screw-cover type **OR** Flanged-and-gasketed type **OR** As indicated, **as directed**.
4. Finish: Manufacturer's standard enamel finish.

E. Nonmetallic Wireways
1. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
OR
Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

F. Surface Raceways
1. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected **OR** Prime coating, ready for field painting, **as directed**.
2. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected from manufacturer's standard **OR** custom, **as directed**, colors.

G. Boxes, Enclosures, And Cabinets
1. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
2. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy **OR** aluminum, **as directed**, Type FD, with gasketed cover.
3. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
4. Metal Floor Boxes: Cast metal **OR** Sheet metal, **as directed**, fully adjustable **OR** semi-adjustable, **as directed**, rectangular.
5. Nonmetallic Floor Boxes: Nonadjustable, round.
6. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
7. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum **OR** galvanized, cast iron, **as directed**, with gasketed cover.
8. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
   a. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   b. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint, **as directed**.
9. Cabinets:
   a. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
   b. Hinged door in front cover with flush latch and concealed hinge.
   c. Key latch to match panelboards.
   d. Metal barriers to separate wiring of different systems and voltage.
   e. Accessory feet where required for freestanding equipment.

H. Handholes And Boxes For Exterior Underground Wiring
1. Description: Comply with SCTE 77.
   a. Color of Frame and Cover: Gray **OR** Green **as directed**.
   b. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
   c. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
   d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
   e. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** as indicated for each service, **as directed**.

f. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
g. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
3. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
4. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete **OR** reinforced concrete **OR** cast iron **OR** hot-dip galvanized-steel diamond plate **OR** fiberglass, **as directed**.

I. Sleeves For Raceways
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Through-penetration Firestop Systems".

J. Sleeve Seals
1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

K. Source Quality Control For Underground Enclosures
1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
a. Tests of materials shall be performed by a independent testing agency.
b. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
c. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

1.3 EXECUTION

A. Raceway Application
1. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
a. Exposed Conduit: Rigid steel conduit **OR** IMC **OR** RNC, Type EPC-40-PVC **OR** RNC, Type EPC-80-PVC, **as directed**.
b. Concealed Conduit, Aboveground: Rigid steel conduit **OR** IMC **OR** EMT **OR** RNC, Type EPC-40-PVC, **as directed**.
c. Underground Conduit: RNC, Type EPC-40 **OR** 80, **as directed**,-PVC, direct buried.

d. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC **OR** LFNC, **as directed**.
e. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R **OR** 4, **as directed**.
f. Application of Handholes and Boxes for Underground Wiring:
1) Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete **OR** Fiberglass enclosures with polymer-concrete frame and cover **OR** Fiberglass-reinforced polyester resin, **as directed**, SCTE 77, Tier 15 structural load rating.
2) Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units **OR** Heavy-duty fiberglass units with polymer-concrete frame and cover, **as directed**, SCTE 77, Tier 8 structural load rating.
3) Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.

2. Comply with the following indoor applications, unless otherwise indicated:
a. Exposed, Not Subject to Physical Damage: EMT **OR** ENT **OR** RNC, **as directed**.
b. Exposed, Not Subject to Severe Physical Damage: EMT **OR** RNC identified for such use, **as directed**.
c. Exposed and Subject to Severe Physical Damage: Rigid steel conduit **OR** IMC, **as directed**. Includes raceways in the following locations:
1) Loading dock.
2) Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
3) Mechanical rooms.
d. Concealed in Ceilings and Interior Walls and Partitions: EMT **OR** ENT **OR** RNC, Type EPC-40-PVC, **as directed**.
e. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
f. Damp or Wet Locations: Rigid steel conduit **OR** IMC, **as directed**.
g. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
h. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
i. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway **OR** Riser-type, optical fiber/communications cable raceway **OR** Plenum-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
j. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel **OR** nonmetallic, **as directed**, in damp or wet locations.

3. Minimum Raceway Size: 1/2-inch (16-mm) **OR** 3/4-inch (21-mm), **as directed**, trade size.
4. Raceway Fittings: Compatible with raceways and suitable for use and location.
a. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
b. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
5. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
6. Do not install aluminum conduits in contact with concrete.

B. Installation
1. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
2. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

3. Complete raceway installation before starting conductor installation.
4. Support raceways as specified in Division 16 Section(s) "Hangers And Supports For Electrical Systems" AND "Vibration And Seismic Controls For Electrical Systems".
5. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
6. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
7. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
8. Raceways Embedded in Slabs:
   a. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   b. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
   c. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
9. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
10. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
11. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
12. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
    a. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
    b. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
    c. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
13. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
    a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
    b. Where otherwise required by NFPA 70.
14. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
    a. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
       1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
       2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
       3) Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
       4) Attics: 135 deg F (75 deg C) temperature change.
    b. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.

c. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

15. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed lighting fixtures, **as directed**, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
    a. Use LFMC in damp or wet locations subject to severe physical damage.
    b. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
16. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
17. Set metal floor boxes level and flush with finished floor surface.
18. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

C. Installation Of Underground Conduit
1. Direct-Buried Conduit:
    a. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 02 Section "Earthwork" for pipe less than 6 inches (150 mm) in nominal diameter.
    b. Install backfill as specified in Division 02 Section "Earthwork"
    c. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 02 Section "Earthwork".
    d. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
    OR
    Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
        1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
        OR
        For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
    e. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of conduit.

D. Installation Of Underground Handholes And Boxes
1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
4. Install handholes and boxes with bottom below the frost line, <**Insert depth of frost line below grade at Project site**> below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.

6. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

E. Sleeve Installation For Electrical Penetrations
1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Through-penetration Firestop Systems".
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
   b. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
8. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies, **as directed**.
10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Through-penetration Firestop Systems".
12. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
13. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

F. Sleeve-Seal Installation
1. Install to seal underground, exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

G. Firestopping
1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Through-penetration Firestop Systems".

H. Protection
1. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

a. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
b. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 16130

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Task	Specification	Specification Description
16130	16120d	Undercarpet Cables
16130	16113	Underfloor Raceways For Electrical Systems

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SECTION 16131 - ELECTRICAL RENOVATION

DESCRIPTION OF WORK

This specification covers the furnishing and installation of materials for electrical renovation. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

GENERAL

Quality Assurance

1. Regulatory Requirements: Comply with following:
   a. Electrical: National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).
   b. Accessibility:
      1) Architectural Barriers Act of 1968 as amended (42 USC 4152-4157) and HUD implementing regulations (24 CFR Part 40).
         a) Uniform Federal Accessibility Standards (UFAS).
      2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
      3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
      4) Americans with Disabilities Act of 1990 (ADA) (28 CFR Part 35).

Project Conditions

2. Existing Conditions: Buildings will be occupied during construction. See Division 1 Section “Summary of Work.” Do not interfere with use of occupied portions of building. Maintain free and safe passage to and from occupied areas.

Scheduling And Sequencing

3. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.

Alterations, Cutting And Protection

4. Protection: Protect existing finishes, equipment, utilities and adjacent work, which is scheduled to remain, from damage.
5. Existing Operating Facilities: Confine operations to immediate vicinity of new work and do not interfere with or obstruct ingress or egress to and from adjacent facilities.

PRODUCTS

Materials

6. Electrical Materials and Devices: Comply with NFPA 70 (NEC):
   a. Boxes: Galvanized steel, not less than 1.6 mm (0.0625 inch) thickness (NEC 370-20) grounded in accordance with NEC, Article 250, suitable for recess mounting.
      1) Provide boxes of appropriate shape and size for intended purpose.
   b. Devices:
      1) Duplex Receptacles: 15 A or 20 A 115 V, UL Listed with screw side connections and corrugated bearing pads.
         a) GFIC Outlets: 115 V, 60 Hz, 15/20 A rating, UL Listed.
      2) Switches: 15 A. 115 V, single pole, single throw switch, UL Listed, with side screw connections and corrugated bearing pads.

a) Garbage Disposal: Heavy duty, 120/277 VAC, 60 Hz, single pole, single throw, 20 A rate, UL listed and CSA certified.

3) Cover Plates: Smooth plastic in color to match existing.

c. Wiring: Insulated wire, Type NM 600 V with ground wire, sized as appropriate for intended purpose and in accordance with NEC.

1) Aluminum Wire: Not allowed unless existing wiring is aluminum.

2) Provide necessary fittings in accordance with NEC.

EXECUTION

Examination

7. Units, Spaces and Areas to be Renovated: Inspect to become familiar with existing conditions and to take measurements which are necessary for renovation work to be completed in accordance with contract requirements.

a. Carefully inspect condition of existing spaces including, but not limited to walls, floors, plumbing, electrical, etc. as essential to successful completion of renovation work.

b. Survey each space and verify dimensions for work.

Preparation

8. Building Occupation: Carry out renovation work to cause as little inconvenience to occupants as possible. See Division 1 Section “Summary of Work.”

9. Protection: Protect and be responsible for existing buildings, facilities, utilities, and improvements within areas of construction operations.

a. Tenant's Property: Be responsible for any damage or loss to residents' property and to other work. Replace any material, which, in opinion of the Owner, has become damaged to extent that it could not be restored to its original condition.

b. Take precautions to protect residents and public from injury from construction operations.

Laying Out Work

10. Discrepancies: Verify dimensions and elevations indicated in layout of existing work.

a. Prior to commencing work, carefully compare and check Drawings (if any), for discrepancies in locations or elevations of work to be executed.

b. Refer discrepancies among Drawings (if any), Specifications and existing conditions to the Owner for adjustment before work affected is performed.

1) Failure to make such notification shall place responsibility on Contractor to carry out work in satisfactory, workmanlike manner.

11. Contractor: Responsible for location and elevation of construction contemplated by Construction Documents.

Location Of Equipment And Piping

12. Drawings (if any) indicating location of equipment, piping, ductwork, etc. are diagrammatic and job conditions shall not always permit their installation in location shown. When this situation occurs, bring condition to the Owner's attention immediately. Relocation will be determined in joint conference.

13. Contractor: Do not relocate any items without first obtaining the Owner's acceptance. Remove and relocate such relocated items at own expense if so directed.

Electrical Work

14. General: Install boxes, wiring, and devices as indicated and required to connect and control electrical devices in accordance with NFPA 70 (NEC).

a. Boxes: Solidly anchor to framing or blocking.

15. Removing Electrical Switch or Duplex Outlet (Non-Hazardous Locations):

a. Box to Remain:

1) Remove electrical device; cap hot and neutral with set-screw wire connectors.

2) Attach ground wire to remaining box with solid screw attachment.
3) Provide and install natural finish aluminum blank cover plate with screw fasteners integral to match size of box remaining.

b. Box to be removed:
1) Remove electrical device and box and pull wire out of wall back to first circuit panel, disconnecting from circuit panel.
2) Patch and repair hole in partition to match existing.

16. Garbage Disposal Electrical Hook-up: See Division 15 Section “Plumbing.” Comply with NFPA 70 (NEC):
a. Wiring: Install from disposal through concealed spaces to house panel, anchoring wire, and providing necessary fittings.
b. Switch: Install above counter top backsplash.

17. Range Hood Electrical Hook-up: See Division 11 Section “Residential Appliances.” Comply with NFPA 70 (NEC):
a. Electric service: Install insulated wire from range hood through concealed spaces to house panel, anchoring wire, and providing necessary fittings.

18. Water Heater Electrical Hook-up: See Division 15 Section “Domestic Water Heaters.” Comply with NFPA 70 (NEC).

19. Furnace Electrical Hook-up: See Division 15 Section “Furnaces.” Comply with NFPA 70 (NEC).

20. Smoke Detector Electrical Hook-up: See Division 13 Section “Fire Alarm.” Comply with NFPA 70 (NEC).

Integrating Existing Work

21. Protection: Protect existing improvements from damage.
a. Where new work is to be connected to existing work, exercise special care not to disturb or damage existing work more than necessary.
b. Damaged Work: Replace, repair and restored to its original condition at no cost to Owner.

END OF SECTION 16131

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Task	Specification	Specification Description
16131	16120	Common Work Results for Electrical
16131	16120a	Common Work Results for Communications
16131	16120b	Common Work Results for Electronic Safety and Security
16131	16120g	Communications Equipment Room Fittings
16131	16120h	Communications Backbone Cabling
16131	16120i	Communications Horizontal Cabling
16131	16120j	Conductors and Cables for Electronic Safety and Security
16134	01352	No Specification Required
16134	16131	Electrical Renovation
16134	16130	Raceways And Boxes
16134	16113	Underfloor Raceways For Electrical Systems
16134	16140	Wiring Devices

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SECTION 16139 - CABLE TRAYS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of cable trays. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes steel, aluminum, stainless-steel, and fiberglass cable trays and accessories.

C. Submittals
1. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
2. Shop Drawings: For each type of cable tray.
   a. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
   b. Seismic-Restraint Details, **as directed**: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
      1) Design Calculations: Calculate requirements for selecting seismic restraints.
      2) Detail fabrication, including anchorages and attachments to structure and to supported cable trays.
3. Field quality-control reports.
4. Operation and Maintenance Data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

E. Delivery, Storage, And Handling
1. Steel cable tray, hot dip galvanized after fabrication, **OR** Aluminum cable tray **OR** Stainless-steel cable tray **OR** Fiberglass cable tray, ,**as directed** may be stored outside without cover, but shall be loosely stacked, elevated off the ground, and ventilated to prevent staining during storage.
2. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.
3. Steel, mill galvanized **OR** electrogalvanized **OR** factory-primed, **as directed**, cable tray shall be stored in a well-ventilated, dry location. Unpack and dry wet materials before storage.
4. PVC-coated **OR** Field-painted, **as directed**, cable tray shall be stored indoors. Protect cable tray from scratching and marring of finish. Unpack and dry wet materials before storage.

1.2 PRODUCTS

A. Materials And Finishes
1. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.

a. Factory-standard primer, ready for field painting; with cadmium-plated hardware according to ASTM B 766.
b. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, G90 (Z275) coating; with hardware galvanized according to ASTM B 633 **OR** cadmium plated according to ASTM B 766, **as directed**.
c. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.
d. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class B2; with chromium-zinc, ASTM F 1136, **OR** Type 316 stainless-steel, **as directed**, hardware.
e. PVC coating applied in a fluidized bed or by electrostatic spray; with chromium-zinc, ASTM F 1136 **OR** Type 316 stainless-steel, **as directed**, hardware.
f. Epoxy-resin paint over paint manufacturer's recommended primer and corrosion-inhibiting treatment; with cadmium-plated hardware according to ASTM B 766 **OR** Type 316 stainless-steel hardware, **as directed**.

2. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts; with chromium-zinc, ASTM F 1136, **OR** Type 316 stainless-steel, **as directed**, splice-plate fasteners, bolts, and screws
3. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304 **OR** 316, **as directed**, complying with NEMA VE 1.
4. Cable Trays, Fittings, and Accessories: Fiberglass, complying with NEMA FG 1 and UL 568. Splice-plate fasteners, bolts, and screws shall be fiberglass-encapsulated stainless steel. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
5. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
   a. Center-hanger supports may be used only when specifically indicated.

B. Cable Tray Accessories
1. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
2. Covers: Solid **OR** Louvered **OR** Ventilated-hat **OR** 2-in-3 pitch cover, **as directed**, type of same materials and finishes as cable tray.
3. Barrier Strips: Same materials and finishes as cable tray.
4. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

C. Warning Signs
1. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
2. Materials and fastening are specified in Division 16 Section "Electrical Identification".

1.3 EXECUTION

A. Cable Tray Installation
1. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
2. Remove burrs and sharp edges from cable trays.
3. Fasten cable tray supports to building structure and install seismic restraints, **as directed**.
   a. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

b. Place supports so that spans do not exceed maximum spans on schedules.
c. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
d. Support bus assembly to prevent twisting from eccentric loading.
e. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
f. Locate and install supports according to NEMA FG 1 **OR** NEMA VE 1, **as directed**.

4. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
5. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA FG 1 **OR** NEMA VE 1, **as directed**. Space connectors and set gaps according to applicable standard.
6. Make changes in direction and elevation using standard fittings.
7. Make cable tray connections using standard fittings.
8. Seal penetrations through fire and smoke barriers according to Division 07 Section "Through-penetration Firestop Systems".
9. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
10. Workspace: Install cable trays with enough space to permit access for installing cables.
11. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
12. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

B. Cable Installation
1. Install cables only when cable tray installation has been completed and inspected.
2. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
3. On vertical runs, fasten cables to tray every 18 inches (457 mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
4. In existing construction, remove inactive or dead cables from cable tray.
5. Install covers after installation of cable is completed.

C. Connections
1. Ground cable trays according to manufacturer's written instructions.
2. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

D. Field Quality Control
1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
a. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
b. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
c. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
d. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.

e. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

f. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

g. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.

2. Report results in writing.

E. Protection

1. Protect installed cable trays.

a. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.

b. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.

c. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION 16139

SECTION 16140 - WIRING DEVICES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of wiring devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Receptacles, receptacles with integral GFCI, and associated device plates.
b. Twist-locking receptacles.
c. Receptacles with integral surge suppression units.
d. Wall-box motion sensors.
e. Isolated-ground receptacles.
f. Hospital-grade receptacles.
g. Snap switches and wall-box dimmers.
h. Solid-state fan speed controls.
i. Wall-switch and exterior occupancy sensors.
j. Communications outlets.
k. Pendant cord-connector devices.
l. Cord and plug sets.
m. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

C. Definitions
1. EMI: Electromagnetic interference.
2. GFCI: Ground-fault circuit interrupter.
3. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
4. RFI: Radio-frequency interference.
5. TVSS: Transient voltage surge suppressor.
6. UTP: Unshielded twisted pair.

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
3. Samples: One for each type of device and wall plate specified, in each color specified.
4. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Straight Blade Receptacles
1. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

2. Hospital-Grade, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement SD.
3. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
   a. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
4. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
   a. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

B. GFCI Receptacles
1. General Description: Straight blade, feed **OR** non-feed, **as directed**,-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
2. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
3. Hospital-Grade, Duplex GFCI Convenience Receptacles, 125 V, 20 A: Comply with UL 498 Supplement SD.

C. TVSS Receptacles
1. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.
   a. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
   b. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
2. Duplex TVSS Convenience Receptacles:
   a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
3. Isolated-Ground, Duplex Convenience Receptacles:
   a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
4. Hospital-Grade, Duplex Convenience Receptacles: Comply with UL 498 Supplement SD.
   a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
5. Isolated-Ground, Hospital-Grade, Duplex Convenience Receptacles:
   a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Comply with UL 498 Supplement SD. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

D. Hazardous (Classified) Location Receptacles
1. Available Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.

E. Twist-Locking Receptacles
1. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
2. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
   a. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw

terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

F. Pendant Cord-Connector Devices
1. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
   a. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
   b. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

G. Cord And Plug Sets
1. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   a. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
   b. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

H. Snap Switches
1. Comply with NEMA WD 1 and UL 20.
2. Switches, 120/277 V, 20 A:
3. Pilot Light Switches, 20 A:
   a. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
4. Key-Operated Switches, 120/277 V, 20 A:
   a. Description: Single pole, with factory-supplied key in lieu of switch handle.
5. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
6. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

I. Wall-Box Dimmers
1. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: Continuously adjustable slider **OR** toggle switch **OR** rotary knob, **as directed**; with single-pole or three-way switching. Comply with UL 1472.
3. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
   a. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF," **as directed**.
4. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

J. Fan Speed Controls
1. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
   a. Continuously adjustable slider **OR** toggle switch **OR** rotary knob, **as directed**, 5 A **OR** 1.5 A, **as directed**.
   b. Three-speed adjustable slider **OR** rotary knob, **as directed**, 1.5 A.

K. Occupancy Sensors
1. Wall-Switch Sensors:

a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).

2. Wall-Switch Sensors:
   a. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
3. Long-Range Wall-Switch Sensors:
   a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).
4. Long-Range Wall-Switch Sensors:
   a. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of 1200 sq. ft. (111 sq. m).
5. Wide-Range Wall-Switch Sensors:
   a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of 1200 sq. ft. (111 sq. m).
6. Exterior Occupancy Sensors:
   a. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and 110-foot (34-m) detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.

L. Communications Outlets
1. Telephone Outlet:
   a. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.
2. Combination TV and Telephone Outlet:
   a. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

M. Wall Plates
1. Single and combination types to match corresponding wiring devices.
   a. Plate-Securing Screws: Metal with head color to match plate finish.
   b. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting **OR** Smooth, high-impact thermoplastic **OR** 0.035-inch- (1-mm-) thick, satin-finished stainless steel **OR** 0.04-inch- (1-mm-) thick, brushed brass with factory polymer finish **OR** 0.05-inch- (1.2-mm-) thick anodized aluminum **OR** 0.04-inch- (1-mm-) thick steel with chrome-plated finish, **as directed**.
   c. Material for Unfinished Spaces: Galvanized steel **OR** Smooth, high-impact thermoplastic, **as directed**.
   d. Material for Damp Locations: Thermoplastic **OR** Cast aluminum, **as directed**, with spring-loaded lift cover, and listed and labeled for use in "wet locations."
2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum **OR** thermoplastic, **as directed**, with lockable cover.

N. Floor Service Fittings
1. Type: Modular, flush-type **OR** flap-type **OR** above-floor, **as directed**, dual-service units suitable for wiring method used.
2. Compartments: Barrier separates power from voice and data communication cabling.
3. Service Plate: Rectangular **OR** Round, **as directed**, die-cast aluminum **OR** solid brass, **as directed**, with satin finish.
4. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
5. Voice and Data Communication Outlet: Blank cover with bushed cable opening **OR** Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable, **as directed**.

O. Poke-Through Assemblies

1. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
   a. Service Outlet Assembly: Pedestal type with services indicated **OR** Flush type with two simplex receptacles and space for two RJ-45 jacks **OR** Flush type with four simplex receptacles and space for four RJ-45 jacks, **as directed**.
   b. Size: Selected to fit nominal 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, cored holes in floor and matched to floor thickness.
   c. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
   d. Closure Plug: Arranged to close unused 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, cored openings and reestablish fire rating of floor.
   e. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two **OR** four, **as directed**, 4-pair, Category 5e voice and data communication cables.

P. Multioutlet Assemblies
1. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
2. Raceway Material: Metal, with manufacturer's standard finish **OR** PVC, **as directed**.
3. Wire: No. 12 AWG.

Q. Service Poles
1. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
   a. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
   b. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
   c. Finishes: Manufacturer's standard painted finish and trim combination **OR** Satin-anodized aluminum, **as directed**.
   d. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
   e. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
   f. Voice and Data Communication Outlets: Blank insert with bushed cable opening **OR** Two RJ-45 Category 5e jacks **OR** Four RJ-45 Category 5e jacks, **as directed**.

R. Finishes
1. Color: Wiring device catalog numbers in Section Text do not designate device color.
   a. Wiring Devices Connected to Normal Power System: Almond **OR** Black **OR** Brown **OR** Gray **OR** Ivory **OR** White **OR** As selected, **as directed**, unless otherwise indicated or required by NFPA 70 or device listing.
   b. Wiring Devices Connected to Emergency Power System: Red.
   c. TVSS Devices: Blue.
   d. Isolated-Ground Receptacles: Orange **OR** As specified above, with orange triangle on face, **as directed**.

1.3 EXECUTION

A. Installation
1. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
2. Coordination with Other Trades:

a. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
b. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
c. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
d. Install wiring devices after all wall preparation, including painting, is complete.

3. Conductors:
   a. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
   b. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
   c. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
   d. Existing Conductors:
      1) Cut back and pigtail, or replace all damaged conductors.
      2) Straighten conductors that remain and remove corrosion and foreign matter.
      3) Pigtailing existing conductors is permitted provided the outlet box is large enough.
4. Device Installation:
   a. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
   b. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
   c. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
   d. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
   e. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
   f. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
   g. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
   h. Tighten unused terminal screws on the device.
   i. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
5. Receptacle Orientation:
   a. Install ground pin of vertically mounted receptacles up **OR** down, **as directed**, and on horizontally mounted receptacles to the right **OR** left, **as directed**.
   b. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
6. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
7. Dimmers:
   a. Install dimmers within terms of their listing.
   b. Verify that dimmers used for fan speed control are listed for that application.
   c. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
8. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
9. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

B. Identification
   1. Comply with Division 16 Section "Electrical Identification".
      a. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black **OR** white **OR** red, **as directed**,-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

C. Field Quality Control
   1. Perform tests and inspections and prepare test reports.
      a. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
      b. Test Instruments: Use instruments that comply with UL 1436.
      c. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
   2. Tests for Convenience Receptacles:
      a. Line Voltage: Acceptable range is 105 to 132 V.
      b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
      c. Ground Impedance: Values of up to 2 ohms are acceptable.
      d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
      e. Using the test plug, verify that the device and its outlet box are securely mounted.
      f. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
   3. Test straight blade convenience outlets in patient-care areas **OR** hospital-grade convenience outlets, **as directed**, for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION 16140

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Task	Specification	Specification Description
16140	16130	Raceways And Boxes

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SECTION 16150 - COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of common motor requirements for equipment. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, alternating-current, small and medium, squirrel-cage induction motors, installed at equipment manufacturer's factory, and motors shipped separately by equipment manufacturer for field installation.

C. Coordination
1. Coordinate features of motors, installed units, and accessory devices and features to be compatible with the following:
a. Motor controllers.
b. Torque, speed, and horsepower requirements of the load.
c. Ratings and characteristics of supply circuit and required control sequence.
d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements
1. Comply with requirements in this Section except when stricter requirements are specified in equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors
1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
a. For motors with 2:1 speed ratio, consequent pole, single winding.
b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Rotor: Random-wound, squirrel cage.
6. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
7. Temperature Rise: Match insulation rating.
8. Insulation: Class F.
9. Code Letter Designation:
a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
b. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

10. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements
1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors
1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   a. Permanent-split capacitor.
   b. Split phase.
   c. Capacitor start, inductor run.
   d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 16150

SECTION 16150a - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common motor requirements for fire suppression equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Coordination
1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   a. Motor controllers.
   b. Torque, speed, and horsepower requirements of the load.
   c. Ratings and characteristics of supply circuit and required control sequence.
   d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements
1. Comply with requirements in this Section except when stricter requirements are specified in fire suppression equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors
1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
   a. For motors with 2:1 speed ratio, consequent pole, single winding.
   b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:

a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   a. Permanent-split capacitor.
   b. Split phase.
   c. Capacitor start, inductor run.
   d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 16150a

SECTION 16150b - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common motor requirements for plumbing equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Coordination
1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   a. Motor controllers.
   b. Torque, speed, and horsepower requirements of the load.
   c. Ratings and characteristics of supply circuit and required control sequence.
   d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements
1. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors
1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
   a. For motors with 2:1 speed ratio, consequent pole, single winding.
   b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
    a. Motors 15 HP and Larger: NEMA starting Code F or Code G.

b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   a. Permanent-split capacitor.
   b. Split phase.
   c. Capacitor start, inductor run.
   d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 16150b

SECTION 16150c - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for common motor requirements for HVAC equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

C. Coordination
1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
   a. Motor controllers.
   b. Torque, speed, and horsepower requirements of the load.
   c. Ratings and characteristics of supply circuit and required control sequence.
   d. Ambient and environmental conditions of installation location.

1.2 PRODUCTS

A. General Motor Requirements
1. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

B. Motor Characteristics
1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. Polyphase Motors
1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
   a. For motors with 2:1 speed ratio, consequent pole, single winding.
   b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
    a. Motors 15 HP and Larger: NEMA starting Code F or Code G.

b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   a. Permanent-split capacitor.
   b. Split phase.
   c. Capacitor start, inductor run.
   d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 16150c

Task	Specification	Specification Description
16155	01352	No Specification Required

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SECTION 16181 - FUSES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for fuses. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, panelboards, switchboards, enclosed controllers, and motor-control centers.
b. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches, fuseholders, and panelboards.
c. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
d. Spare-fuse cabinets.

C. Submittals
1. Product Data: For each type of product indicated.
2. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA FU 1 for cartridge fuses.
3. Comply with NFPA 70.
4. Comply with UL 248-11 for plug fuses.

E. Project Conditions
1. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.2 PRODUCTS

A. Cartridge Fuses
1. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

B. Plug Fuses
1. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

C. Plug-Fuse Adapters
1. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

D. Spare-Fuse Cabinet
1. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
a. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

b. Finish: Gray, baked enamel.
c. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
d. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

1.3 EXECUTION

A. Fuse Applications
1. Cartridge Fuses:
a. Service Entrance: Class L, fast acting **OR** Class L, time delay **OR** Class RK1, fast acting **OR** Class RK1, time delay **OR** Class J, fast acting **OR** Class J, time delay **OR** Class T, fast acting, **as directed**.
b. Feeders: Class L, fast acting **OR** Class L, time delay **OR** Class RK1, fast acting **OR** Class RK1, time delay **OR** Class RK5, fast acting **OR** Class RK5, time delay **OR** Class J, fast acting **OR** Class J, time delay, **as directed**.
c. Motor Branch Circuits: Class RK1 **OR** Class RK5, **as directed**, time delay.
d. Other Branch Circuits: Class RK1, time delay **OR** Class RK5, time delay **OR** Class J, fast acting **OR** Class J, time delay, **as directed**.
e. Control Circuits: Class CC, fast acting **OR** time delay, **as directed**.
2. Plug Fuses:
a. Motor Branch Circuits: Edison-base type, dual **OR** Edison-base type, single **OR** Type S, dual **OR** Type S, single, **as directed**,-element time delay.
b. Other Branch Circuits: Edison-base type, single-element fast acting **OR** Edison-base type, dual-element time delay **OR** Edison-base type, single-element time delay **OR** Type S, dual-element time delay **OR** Type S, single-element time delay, **as directed**.

B. Installation
1. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
2. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.
3. Install spare-fuse cabinet(s).

C. Identification
1. Install labels complying with requirements for identification specified in Division 16 Section "Electrical Identification" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 16181

SECTION 16190 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for hangers and supports for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Hangers and supports for electrical equipment and systems.
b. Construction requirements for concrete bases.

C. Definitions
1. EMT: Electrical metallic tubing.
2. IMC: Intermediate metal conduit.
3. RMC: Rigid metal conduit.

D. Performance Requirements
1. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
3. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
4. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

E. Submittals
1. Product Data: For the following:
a. Steel slotted support systems.
b. Nonmetallic slotted support systems.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
a. Trapeze hangers. Include Product Data for components.
b. Steel slotted channel systems. Include Product Data for components.
c. Nonmetallic slotted channel systems. Include Product Data for components.
d. Equipment supports.
3. Welding certificates.

F. Quality Assurance
1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Support, Anchorage, And Attachment Components

1. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
   b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
   c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
   d. Channel Dimensions: Selected for applicable load criteria.
2. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
   a. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
   b. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
   c. Rated Strength: Selected to suit applicable load criteria.
3. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
4. Conduit and Cable Support Devices: Steel **OR** Steel and malleable-iron, **as directed**, hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
5. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
6. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
7. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
   a. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   b. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel **OR** stainless steel, **as directed**, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   c. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
   d. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
   e. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
   f. Toggle Bolts: All-steel springhead type.
   g. Hanger Rods: Threaded steel.

B. Fabricated Metal Equipment Support Assemblies
1. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
2. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

1.3 EXECUTION

A. Application
1. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
2. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by **OR** scheduled in NECA 1, where its Table 1 lists maximum

spacings less than stated in, **as directed**, NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

3. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   a. Secure raceways and cables to these supports with two-bolt conduit clamps **OR** single-bolt conduit clamps **OR** single-bolt conduit clamps using spring friction action for retention in support channel, **as directed**.
4. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

B. Support Installation
1. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
2. Raceway Support Methods: In addition to methods described in NECA 1, EMT **OR** IMC **OR** RMC, **as directed**, may be supported by openings through structure members, as permitted in NFPA 70.
3. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
4. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
   a. To Wood: Fasten with lag screws or through bolts.
   b. To New Concrete: Bolt to concrete inserts.
   c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   d. To Existing Concrete: Expansion anchor fasteners.
   e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
   f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts **OR** Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 **OR** Spring-tension clamps, **as directed**.
   g. To Light Steel: Sheet metal screws.
   h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
5. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

C. Installation Of Fabricated Metal Supports
1. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
3. Field Welding: Comply with AWS D1.1/D1.1M.

D. Concrete Bases
1. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

2. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-place Concrete".
3. Anchor equipment to concrete base.
   a. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   b. Install anchor bolts to elevations required for proper attachment to supported equipment.
   c. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

E. Painting
1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
2. Touchup: Comply with requirements in Division 07 OR Division 09 Section(s) "High-performance Coatings" **as directed,** for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 16190

SECTION 16190a - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for vibration and seismic controls for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Isolation pads.
b. Spring isolators.
c. Restrained spring isolators.
d. Channel support systems.
e. Restraint cables.
f. Hanger rod stiffeners.
g. Anchorage bushings and washers.

C. Definitions
1. The IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

D. Performance Requirements
1. Seismic-Restraint Loading:
a. Site Class as Defined in the IBC: A **OR** B **OR** C **OR** D **OR** E **OR** F, **as directed**.
b. Assigned Seismic Use Group or Building Category as Defined in the IBC: I **OR** II **OR** III, **as directed**.
1) Component Importance Factor: 1.0 **OR** 1.5, **as directed**.
2) Component Response Modification Factor: 1.5 **OR** 2.5 **OR** 3.5 **OR** 5.0, **as directed**.
3) Component Amplification Factor: 1.0 **OR** 2.5, **as directed**.
c. Design Spectral Response Acceleration at Short Periods (0.2 Second): As required to meet Project requirements.
d. Design Spectral Response Acceleration at 1.0-Second Period: As required to meet Project requirements.

E. Submittals
1. Product Data: For the following:
a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
1) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2) Annotate to indicate application of each product submitted and compliance with requirements.
c. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

a. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
   1) Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 15 for equipment mounted outdoors.
b. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
c. Field-fabricated supports.
d. Seismic-Restraint Details:
   1) Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   2) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   3) Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

3. Welding certificates.
4. Field quality-control test reports.

F. Quality Assurance
1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
4. Comply with NFPA 70.

1.2 PRODUCTS

A. Vibration Isolators
1. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
   a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
   a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

e. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).

f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

3. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

b. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.

c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

d. Minimum Additional Travel: 50 percent of the required deflection at rated load.

e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

B. Seismic-Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.

a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

3. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod. Do not weld stiffeners to rods.

5. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

7. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

8. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

9. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

C. Factory Finishes

1. Finish:
   a. Manufacturer's standard prime-coat finish ready for field painting.
   b. Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
      1) Powder coating on springs and housings.
      2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
      3) Baked enamel or powder coat for metal components on isolators for interior use.
      4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

1.3 EXECUTION

A. Applications
   1. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
   2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
   3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Seismic-Restraint Device Installation
   1. Equipment and Hanger Restraints:
      a. Install restrained isolators on electrical equipment.
      b. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
      c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
   2. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
   3. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
   4. Drilled-in Anchors:
      a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
      b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
      c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
      d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
      e. Set anchors to manufacturer's recommended torque, using a torque wrench.
      f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

C. Accommodation Of Differential Seismic Motion
   1. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

D. Field Quality Control
   1. Tests and Inspections:
      a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
      b. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
      c. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
      d. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
      e. Test to 90 percent of rated proof load of device.
      f. Measure isolator restraint clearance.
      g. Measure isolator deflection.
      h. Verify snubber minimum clearances.
      i. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
   2. Remove and replace malfunctioning units and retest as specified above.
   3. Prepare test and inspection reports.

E. Adjusting
   1. Adjust isolators after isolated equipment is at operating weight.
   2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
   3. Adjust active height of spring isolators.
   4. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 16190a

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SECTION 16211 - PACKAGED ENGINE GENERATORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for packaged engine generators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes packaged engine-generator sets for emergency **OR** standby, **as directed**, power supply with the following features:
   a. Gas and Diesel engine.
   b. Unit-mounted and Remote-mounting cooling system.
   c. Unit-mounted and Remote-mounting control and monitoring.
   d. Performance requirements for sensitive loads.
   e. Load banks.
   f. Outdoor enclosure.

C. Definitions
1. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
2. LP: Liquid petroleum.

D. Submittals
1. Product Data: For each type of packaged engine generator and accessory indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with ASME B15.1.
5. Comply with NFPA 37.
6. Comply with NFPA 70.
7. Comply with NFPA 99 for healthcare facilities.
8. Comply with NFPA 110 requirements for Level 1 **OR** 2, **as directed,** emergency power supply system.

9. Comply with UL 2200.
10. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
11. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Project Conditions
1. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   a. Ambient Temperature: 5 to 40 deg C **OR** Minus 15 to plus 40 deg C, **as directed**.
   b. Relative Humidity: 0 to 95 percent for outdoor units.
   c. Altitude: Sea level to 1000 feet (300 m).
2. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
   a. High salt-dust content in the air due to sea-spray evaporation.

1.2 PRODUCTS

A. Engine-Generator Set
1. Factory-assembled and -tested, engine-generator set.
2. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
   a. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
3. Capacities and Characteristics:
   a. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
   b. Output Connections: Three-phase, three **OR** four, **as directed,** wire.
   c. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
4. Generator-Set Performance:
   a. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
   b. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
   c. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
   d. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
   e. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
   f. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
   g. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
   h. Start Time: Comply with NFPA 110, Type 10, system requirements.

5. Generator-Set Performance for Sensitive Loads:
   a. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
      1) Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
   b. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
   c. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
   d. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
   e. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
   f. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
   g. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
   h. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
   i. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
      1) Provide permanent magnet excitation for power source to voltage regulator.
   j. Start Time: Comply with NFPA 110, Type 10, system requirements.

B. Engine
   1. Fuel: Fuel oil, Grade DF-2 **OR** Natural gas with automatic LP-gas standby **OR** Natural gas, **as directed**.
   2. Rated Engine Speed: 1800 rpm.
   3. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
   4. Lubrication System: The following items are mounted on engine or skid:
      a. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
      b. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
      c. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
   5. Engine Fuel System:
      a. Main Fuel Pump For Diesel-Fueled Engine: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
      b. Relief-Bypass Valve For Diesel-Fueled Engine: Automatically regulates pressure in fuel line and returns excess fuel to source.
      c. Dual Natural Gas with LP-Gas Backup (Vapor-Withdrawal) System:
         1) Carburetor.
         2) Secondary Gas Regulators: One for each fuel type.
         3) Fuel-Shutoff Solenoid Valves: One for each fuel source.
         4) Flexible Fuel Connectors: One for each fuel source.
   6. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
   7. Governor: Adjustable isochronous, with speed sensing.

8. Cooling System:
   a. Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
      1) Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
      2) Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
      3) Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
      4) Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
      5) Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
         a) Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
         b) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
   b. Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
      1) Configuration: Vertical **OR** Horizontal, **as directed,** air discharge.
      2) Radiator Core Tubes: Aluminum **OR** Nonferrous-metal construction other than aluminum, **as directed**.
      3) Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
      4) Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
      5) Fan: Driven by multiple belts from engine shaft **OR** totally enclosed electric motor with sealed bearings, **as directed**.
      6) Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
      7) Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
9. Muffler/Silencer:
   a. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
      1) Minimum sound attenuation of 25 dB at 500 Hz.
      2) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.
   b. Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
      1) Minimum sound attenuation of 18 dB at 500 Hz.
      2) Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 95 dBA or less.
   c. Industrial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
      1) Minimum sound attenuation of 12 dB at 500 Hz.
      2) Sound level measured at a distance of 25 feet (8 m) from exhaust discharge after installation is complete shall be 87 dBA or less.
10. Air-Intake Filter: Standard **OR** Heavy, **as directed,**-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
11. Starting System: 12 **OR** 24, **as directed,**-V electric, with negative ground.

a. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
b. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
c. Cranking Cycle: As required by NFPA 110 for system level specified **OR** 60 seconds, **as directed**.
d. Battery: Adequate capacity within ambient temperature range specified in Part 1.1 "Project Conditions" Article to provide specified cranking cycle at least twice **OR** three times, **as directed**, without recharging.
e. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
f. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1.1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
g. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
h. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.
   1) Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
   2) Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
   3) Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
   4) Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
   5) Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
   6) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

C. Fuel Oil Storage
1. Comply with NFPA 30.
2. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
   a. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
      1) Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
   b. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.
   c. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
   d. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
   e. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.

f. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.

g. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.

3. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

a. Tank level indicator.

b. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.

c. Vandal-resistant fill cap.

d. Containment Provisions: Comply with requirements of authorities having jurisdiction.

D. Control And Monitoring

1. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

2. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

3. Configuration:

a. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

b. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.

c. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:

1) Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.

2) Switchboard Construction: Freestanding unit complying with Division 16 Section "Switchboards".

3) Switchgear Construction: Freestanding unit complying with Division 16 Section "Switchgear".

4) Current and Potential Transformers: Instrument accuracy class.

4. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 **OR** 2, **as directed,** system, and the following:

a. AC voltmeter.

b. AC ammeter.

c. AC frequency meter.

d. DC voltmeter (alternator battery charging).

e. Engine-coolant temperature gage.

f. Engine lubricating-oil pressure gage.

g. Running-time meter.

h. Ammeter-voltmeter, phase-selector switch(es).

i. Generator-voltage adjusting rheostat.
j. Fuel tank derangement alarm.
k. Fuel tank high-level shutdown of fuel supply alarm.
l. Generator overload.

5. Indicating and Protective Devices and Controls:
   a. AC voltmeter.
   b. AC ammeter.
   c. AC frequency meter.
   d. DC voltmeter (alternator battery charging).
   e. Engine-coolant temperature gage.
   f. Engine lubricating-oil pressure gage.
   g. Running-time meter.
   h. Ammeter-voltmeter, phase-selector switch(es).
   i. Generator-voltage adjusting rheostat.
   j. Start-stop switch.
   k. Overspeed shutdown device.
   l. Coolant high-temperature shutdown device.
   m. Coolant low-level shutdown device.
   n. Oil low-pressure shutdown device.
   o. Fuel tank derangement alarm.
   p. Fuel tank high-level shutdown of fuel supply alarm.
   q. Generator overload.
6. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
7. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 16 Section "Electrical Power Monitoring And Control".
8. Common Remote Audible Alarm:
   a. Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
      1) Overcrank shutdown.
      2) Coolant low-temperature alarm.
      3) Control switch not in auto position.
      4) Battery-charger malfunction alarm.
      5) Battery low-voltage alarm.
   b. Common Remote Audible Alarm for manually starting systems or for automatically starting systems not specified to comply with NFPA 110, Level 1, but where some remote alarm functions are needed. Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
      1) Engine high-temperature shutdown.
      2) Lube-oil, low-pressure shutdown.
      3) Overspeed shutdown.
      4) Remote emergency-stop shutdown.
      5) Engine high-temperature prealarm.
      6) Lube-oil, low-pressure prealarm.
      7) Fuel tank, low-fuel level.
      8) Low coolant level.
9. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

10. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

E. Generator Overcurrent And Fault Protection
1. Generator Circuit Breaker:
   a. Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
      1) Tripping Characteristic: Designed specifically for generator protection.
      2) Trip Rating: Matched to generator rating.
      3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
      4) Mounting: Adjacent to or integrated with control and monitoring panel.
   b. Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
      1) Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
      2) Trip Settings: Selected to coordinate with generator thermal damage curve.
      3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
      4) Mounting: Adjacent to or integrated with control and monitoring panel.
   c. Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.
   d. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
   e. Trip Settings: Selected to coordinate with generator thermal damage curve.
   f. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
   g. Mounting: Adjacent to or integrated with control and monitoring panel.
2. Generator Disconnect Switch: Molded-case type, 100 percent rated.
   a. Rating: Matched to generator output rating.
   b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.
3. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
   a. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
   b. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
   c. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
   d. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
   e. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

F. Generator, Exciter, And Voltage Regulator
1. Comply with NEMA MG 1.
2. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
3. Electrical Insulation: Class H or Class F.
4. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

5. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
6. Enclosure: Dripproof.
7. Instrument Transformers: Mounted within generator enclosure.
8. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
   a. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
9. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
10. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
11. Subtransient Reactance: 12 percent, maximum.

G. Load Bank
1. Description: Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive **OR** resistive and reactive, **as directed,** unit capable of providing a balanced 3-phase, delta-connected load to generator set at 100 percent rated-system capacity, at 80 percent power factor, lagging. Unit may be composed of separate resistive and reactive load banks controlled by a common control panel. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
2. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases.
3. Reactive Load Elements: Epoxy-encapsulated reactor coils.
4. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
5. Load Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
6. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
7. Load-Bank Enclosures: NEMA 250, Type 3R, complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch- (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge.
8. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
9. Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
10. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

H. Outdoor Generator-Set Enclosure
1. Description:
   a. Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

b. Prefabricated or preengineered walk-in enclosure with the following features:
   1) Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
   2) Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
   3) Space Heater: Thermostatically controlled and sized to prevent condensation.
   4) Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
   5) Hinged Doors: With padlocking provisions.
   6) Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
   7) Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
   8) Muffler Location: Within **OR** External to, **as directed,** enclosure.

2. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
   a. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
   b. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
   a. AC lighting system and connection point for operation when remote source is available.
   b. DC lighting system for operation when remote source and generator are both unavailable.
4. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

I. Motors
1. General requirements for motors are specified in Division 15 Section "Common Motor Requirements For Hvac Equipment".
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
   b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 15.

J. Vibration Isolation Devices
1. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
   a. Material: Standard neoprene **OR** Natural rubber **OR** Bridge-bearing neoprene, complying with AASHTO M 251, **as directed**.
   b. Durometer Rating: 30 **OR** 40 **OR** 45 **OR** 50 **OR** 60 **OR** 65 **OR** 70, **as directed**.
   c. Number of Layers: One **OR** Two **OR** Three **OR** Four, **as directed**.
2. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
   a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   b. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

K. Finishes
1. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

L. Source Quality Control
1. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
   a. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
   b. Report factory test results within 10 days of completion of test.

1.3 EXECUTION

A. Installation
1. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
2. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
3. Install packaged engine generator with elastomeric isolator pads **OR** restrained spring isolators, **as directed,** having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Install remote radiator with elastomeric isolator pads **OR** restrained spring isolators, **as directed,** having a minimum deflection of 1 inch (25 mm) on concrete base on grade **OR** roof equipment supports on roof, **as directed**.
5. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger **OR** remote radiator, **as directed**. Piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping".
6. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping".
   a. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 15 Section "Hydronic Piping".
7. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
8. Piping installation requirements are specified in Division 15. Drawings indicate general arrangement of piping and specialties.
9. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
10. Connect cooling-system water piping to engine-generator set and remote radiator **OR** heat exchanger, **as directed** with flexible connectors.
11. Connect engine exhaust pipe to engine with flexible connector.
12. Connect fuel piping to engines with a gate valve and union and flexible connector.
    a. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 15 Section "Facility Natural-gas Piping".
    b. LP-gas piping, valves, and specialties for gas piping are specified in Division 15 Section "Facility Liquefied-petroleum Gas Piping".
13. Ground equipment according to Division 16 Section "Grounding And Bonding".
14. Connect wiring according to Division 16 Section "Conductors And Cables".
15. Identify system components according to Division 15 Section "Identification For Hvac Piping And Equipment" and Division 16 Section "Electrical Identification".

B. Field Quality Control

1. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   b. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
   c. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
      1) Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
      2) Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
      3) Verify acceptance of charge for each element of the battery after discharge.
      4) Verify that measurements are within manufacturer's specifications.
   d. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
   e. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
   f. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
   g. Exhaust Emissions Test: Comply with applicable government test criteria.
   h. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
   i. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
   j. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
3. Coordinate tests with tests for transfer switches and run them concurrently.
4. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
5. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
7. Remove and replace malfunctioning units and retest **OR** reinspect, **as directed,** as specified above.
8. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
9. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

C. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 16211

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Task	Specification	Specification Description
16211	01352	No Specification Required

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SECTION 16251 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for enclosed switches and circuit breakers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Fusible switches.
b. Nonfusible switches.
c. Receptacle switches.
d. Shunt trip switches.
e. Molded-case circuit breakers (MCCBs).
f. Molded-case switches.
g. Enclosures.

C. Definitions
1. NC: Normally closed.
2. NO: Normally open.
3. SPDT: Single pole, double throw.

D. Performance Requirements
1. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

E. Submittals
1. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
2. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
a. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
4. Field quality-control reports.
5. Operation and maintenance data.

F. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.

G. Project Conditions
1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

a. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
b. Altitude: Not exceeding 6600 feet (2010 m).

2. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   a. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
   b. Indicate method of providing temporary electric service.
   c. Do not proceed with interruption of electric service without Owner's written permission.
   d. Comply with NFPA 70E.

1.2 PRODUCTS

A. Fusible Switches
1. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge **OR** plug, **as directed**, fuse interiors to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
2. Type HD, Heavy Duty, Single Throw, 240 **OR** 600, **as directed**,-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
3. Type HD, Heavy Duty, Six Pole, Single Throw, 240 **OR** 600, **as directed**,-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
4. Type HD, Heavy Duty, Double Throw, 240 **OR** 600, **as directed**,-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
5. Accessories:
   a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   c. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
   e. Auxiliary Contact Kit: One **OR** Two, **as directed**, NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
   f. Hookstick Handle: Allows use of a hookstick to operate the handle.
   g. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, and conductor material.
   h. Service-Rated Switches: Labeled for use as service equipment.
   i. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

B. Nonfusible Switches
1. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

2. Type HD, Heavy Duty, Single Throw, 240 **OR** 600, **as directed**,-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
3. Type HD, Heavy Duty, Six Pole, Single Throw, 240 **OR** 600, **as directed**,-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
4. Type HD, Heavy Duty, Double Throw, 240 **OR** 600, **as directed**,-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
5. Accessories:
   a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
   b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   c. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
   d. Auxiliary Contact Kit: One **OR** Two, **as directed**, NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
   e. Hookstick Handle: Allows use of a hookstick to operate the handle.
   f. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, and conductor material.
   g. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

C. Receptacle Switches
1. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 240 **OR** 600, **as directed**,-V ac, 30 **OR** 60 **OR** 100, **as directed**, A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
2. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 240 **OR** 600, **as directed**,-V ac, 30 **OR** 60 **OR** 100, **as directed**, A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
3. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
4. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

D. Shunt Trip Switches
1. General Requirements: Comply with ASME A17.1, **as directed**, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
2. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
3. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer **OR** source, **as directed**, of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
4. Accessories:
   a. Oiltight key switch for key-to-test function.
   b. Oiltight red **OR** green **OR** white **OR** yellow, **as directed**, ON pilot light.
   c. Isolated neutral lug; 100 **OR** 200, **as directed**, percent rating.
   d. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
   e. Form C alarm contacts that change state when switch is tripped.

f. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac **OR** 24-V dc, **as directed**, coil voltage.
g. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

E. Molded-Case Circuit Breakers
1. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.
5. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
6. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
7. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
8. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
9. Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, trip ratings, and conductor material.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
   d. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered **OR** remote-mounted and powered, **as directed**, type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   e. Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system, specified in Division 16 Section "Electrical Power Monitoring And Control".
   f. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   h. Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   i. Alarm Switch: One NO **OR** NC, **as directed**, contact that operates only when circuit breaker has tripped.
   j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   k. Zone-Selective Interlocking: Integral with electronic **OR** ground-fault, **as directed**, trip unit; for interlocking ground-fault protection function.
   l. Electrical Operator: Provide remote control for on, off, and reset operations.

m. Accessory Control Power Voltage: Integrally mounted, self-powered **OR** Remote mounted and powered, **as directed**; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

F. Molded-Case Switches

1. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
2. Features and Accessories:
   a. Standard frame sizes and number of poles.
   b. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, trip ratings, and conductor material.
   c. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
   d. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
   e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   f. Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
   g. Alarm Switch: One NO **OR** NC, **as directed**, contact that operates only when switch has tripped.
   h. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
   i. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
   j. Electrical Operator: Provide remote control for on, off, and reset operations.
   k. Accessory Control Power Voltage: Integrally mounted, self-powered **OR** Remote mounted and powered, **as directed**; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

G. Enclosures

1. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
   a. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Kitchen **OR** Wash-Down, **as directed**, Areas: NEMA 250, Type 4X, stainless steel.
   d. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
   e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
   f. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 **OR** Type 9, **as directed**.

1.3 EXECUTION

A. Installation

1. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
2. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
4. Install fuses in fusible devices.
5. Comply with NECA 1.

B. Identification
1. Comply with requirements in Division 16 Section "Electrical Identification".
   a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   b. Label each enclosure with engraved metal or laminated-plastic nameplate.

C. Field Quality Control
1. Perform tests and inspections.
2. Acceptance Testing Preparation:
   a. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
   b. Test continuity of each circuit.
3. Tests and Inspections:
   a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   c. Perform the following infrared scan tests and inspections and prepare reports:
      1) Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
      2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
      3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   d. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
4. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Adjusting
1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
2. Set field-adjustable circuit-breaker trip ranges as specified in Division 16 Section "Overcurrent Protective Device Coordination".

END OF SECTION 16251

SECTION 16251a - TRANSFER SWITCHES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for transfer switches. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes transfer switches rated 600 V and less, including the following:
   a. Automatic transfer switches.
   b. Bypass/isolation switches.
   c. Nonautomatic transfer switches.
   d. Remote annunciation systems.
   e. Remote annunciation and control systems.

C. Submittals
1. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
3. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA ICS 1.
3. Comply with NFPA 70.
4. Comply with NFPA 99.
5. Comply with NFPA 110.
6. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.2 PRODUCTS

A. General Transfer-Switch Product Requirements
1. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
2. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
   a. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
3. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

4. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
5. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
6. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
   a. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
   b. Switch Action: Double throw; mechanically held in both directions.
   c. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
7. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles **OR** overlapping neutral contacts, **as directed**.
8. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
9. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
10. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
11. Battery Charger: For generator starting batteries.
    a. Float type rated 2 **OR** 10, **as directed,** A.
    b. Ammeter to display charging current.
    c. Fused ac inputs and dc outputs.
12. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
13. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 16 Section "Electrical Identification".
    a. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
    b. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
    c. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
14. Enclosures: General-purpose NEMA 250, Type 1 **OR** 3R **OR** 12, **as directed**, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

B. Automatic Transfer Switches
1. Comply with Level 1 equipment according to NFPA 110.
2. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
3. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
4. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
5. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
6. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
7. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
8. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:

a. Fully automatic make-before-break operation.
b. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
c. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   1) Initiation occurs without active control of generator.
   2) Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
d. Failure of power source serving load initiates automatic break-before-make transfer.

9. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
10. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
11. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
12. Automatic Transfer-Switch Features:
    a. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
    b. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
    c. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
    d. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
    e. Test Switch: Simulate normal-source failure.
    f. Switch-Position Pilot Lights: Indicate source to which load is connected.
    g. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
       1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
       2) Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
    h. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
    i. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

j. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
k. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
l. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
m. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
   1) Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
   2) Push-button programming control with digital display of settings.
   3) Integral battery operation of time switch when normal control power is not available.

C. Bypass/Isolation Switches
1. Comply with requirements for Level 1 equipment according to NFPA 110.
2. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
   a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
   b. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
   c. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
   d. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
   e. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
   f. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
   g. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
3. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

D. Nonautomatic Transfer Switches
1. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
2. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
3. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.

4. Nonautomatic Transfer-Switch Accessories:
   a. Pilot Lights: Indicate source to which load is connected.
   b. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternate-source sensing circuits.
      1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
      2) Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
   c. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

E. Remote Annunciator System
1. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
   a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
   b. Switch position.
   c. Switch in test mode.
   d. Failure of communication link.
2. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
   a. Indicating Lights: Grouped for each transfer switch monitored.
   b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
   c. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
   d. Lamp Test: Push-to-test or lamp-test switch on front panel.

F. Remote Annunciator And Control System
1. Functional Description: Include the following functions for indicated transfer switches:
   a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
   b. Indication of switch position.
   c. Indication of switch in test mode.
   d. Indication of failure of digital communication link.
   e. Key-switch or user-code access to control functions of panel.
   f. Control of switch-test initiation.
   g. Control of switch operation in either direction.
   h. Control of time-delay bypass for transfer to normal source.
2. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
3. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
   a. Controls and indicating lights grouped together for each transfer switch.
   b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
   c. Digital Communication Capability: Matched to that of transfer switches supervised.
   d. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.

G. Source Quality Control
1. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

1.3 EXECUTION

A. Installation
1. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounting Switch: Anchor to floor by bolting.
   a. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 16 Section "Hangers And Supports For Electrical Systems".
3. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
4. Identify components according to Division 16 Section "Electrical Identification".
5. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

B. Connections
1. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
2. Ground equipment according to Division 16 Section "Grounding And Bonding".
3. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
   b. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
   c. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   d. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
      1) Check for electrical continuity of circuits and for short circuits.
      2) Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
      3) Verify that manual transfer warnings are properly placed.
      4) Perform manual transfer operation.
   e. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
      1) Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
      2) Simulate loss of phase-to-ground voltage for each phase of normal source.
      3) Verify time-delay settings.
      4) Verify pickup and dropout voltages by data readout or inspection of control settings.
      5) Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

6) Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

f. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

1) Verify grounding connections and locations and ratings of sensors.

3. Coordinate tests with tests of generator and run them concurrently.
4. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
5. Remove and replace malfunctioning units and retest as specified above.
6. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

D. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
2. Coordinate this training with that for generator equipment.

END OF SECTION 16251a

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Task	Specification	Specification Description
16251	01352	No Specification Required

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SECTION 16265 - STATIC UNINTERRUPTIBLE POWER SUPPLY

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for static uninterruptible power supply. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
1) Surge suppression.
2) Input harmonics reduction.
3) Rectifier-charger.
4) Inverter.
5) Static bypass transfer switch.
6) Battery and battery disconnect device.
7) Internal and External maintenance bypass/isolation switch.
8) Output isolation transformer.
9) Remote UPS monitoring provisions.
10) Battery monitoring.
11) Remote monitoring.

C. Definitions
1. EMI: Electromagnetic interference.
2. LCD: Liquid-crystal display.
3. LED: Light-emitting diode.
4. PC: Personal computer.
5. THD: Total harmonic distortion.
6. UPS: Uninterruptible power supply.

D. Performance Requirements
1. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7, **as directed**.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.
2. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.
a. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For UPS equipment, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

4. Factory Test Reports: Comply with specified requirements.
5. Field quality-control reports.
6. Operation and maintenance data.
7. Warranties: Sample of special warranties.

F. Quality Assurance

1. Testing Agency Qualifications: Member company of NETA or an NRTL.
   a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Compliance: Listed and labeled under UL 1778 by an NRTL.
4. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

G. Warranty

1. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
   a. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

OR

Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	40 cycles
30 minutes	30 minutes	1.67	125 cycles
15 minutes	1.5 minutes	1.67	750 cycles

OR

Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of 77 deg F (25 deg C):

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.75	40 cycles
1 hour	1 hour	1.75	80 cycles
15 minutes	45 seconds	1.67	2700 cycles

2. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within Two **OR** Three, **as directed**, years from date of Substantial Completion.

1.2 PRODUCTS

A. Operational Requirements

1. Automatic operation includes the following:
   a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
   b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
   c. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
   d. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
   e. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
   f. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
   g. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
   h. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
   i. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.
2. Manual operation includes the following:
   a. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
   b. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.
3. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:
   a. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
   b. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
   c. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.
4. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.
   a. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).

b. Ambient Temperature for Battery: 41 to 95 deg F (5 to 35 deg C).
c. Relative Humidity: 0 to 95 percent, noncondensing.
d. Altitude: Sea level to 4000 feet (1220 m).

B. Performance Requirements
1. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:
   a. Inverter is switched to battery source.
   b. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
   c. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
   d. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
   e. Load is 30 **OR** 50 **OR** 100, **as directed**, percent unbalanced continuously.
2. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is five **OR** 10 **OR** 15, **as directed**, minutes.
3. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 15 **OR** 20 **OR** 30, **as directed**, percent from nominal voltage.
4. Overall UPS Efficiency:

NOMINAL OVERALL UPS EFFICIENCY RATINGS			
SIZE RANGE OF UPS UNITS	**EFFICIENCY AT 100% RATED LOAD**	**EFFICIENCY AT 75% RATED LOAD**	**EFFICIENCY AT 50% RATED LOAD**
30 kVA and Smaller	86	85	84
37.5 to 74 kVA	89	88	87
75 to 124 kVA	90	88	87
125 to 224 kVA	90	89	88
225 kVA and Larger	90	89	88

5. Maximum Acoustical Noise:

NOMINAL OVERALL UPS AUDIBLE NOISE RATINGS		
SIZE RANGE OF UPS UNITS	**MAXIMUM NOISE VALUE**	**DISTANCE AT WHICH MEASURED**
10 kVA and Smaller	58 dB	36 inches (900 mm)
20 to 125 kVA	60 dB	48 inches (1200 mm)
150 to 300 kVA	78 dB	48 inches (1200 mm)
300 kVA and Larger	83 dB	48 inches (1200 mm)

6. Maximum Energizing Inrush Current: Six **OR** Eight, **as directed**, times the full-load current.
7. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.
8. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.
9. Limitation of harmonic distortion of input current to the UPS shall be as follows:

a. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 5 **OR** 10, **as directed**, percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
OR
Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.

10. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.
OR
Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.
11. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.
12. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:
    a. 50 Percent: Plus or minus 5 percent.
    b. 100 Percent: Plus or minus 5 percent.
    c. Loss of AC Input Power: Plus or minus 1 percent.
    d. Restoration of AC Input Power: Plus or minus 1 percent.
13. Input Power Factor: A minimum of 0.70 **OR** 0.85, **as directed**, lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.
14. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.

C. UPS Systems
1. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
2. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
3. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
4. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch, **as directed**. Protect rectifier-charger, inverter, controls, and output components.
    a. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B **OR** Category C, **as directed**.
    b. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.
5. Maintainability Features (for units rated more than approximately 100 kVA): Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
6. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.
7. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.
8. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

9. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity (for a UPS with heavy nonlinear loading): Rated phase current times a multiple of 1.73, minimum.

D. Rectifier-Charger
1. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
2. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
3. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
   a. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
4. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

E. Inverter
1. Description: Pulse-width modulated, with sinusoidal output.
   OR
   Description (if the UPS may be supplied power from a standby engine-generator set): Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

F. Static Bypass Transfer Switch
1. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.
2. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

G. Battery

ALTERNATIVE BATTERY TYPES FOR UPS SYSTEMS

TYPE	NOMINAL LIFE EXPECTANCY (YEARS)*	TYPICAL WARRANTY (YEARS)*		MINIMUM NOMINAL MAINTENANCE INTERVAL	APPROX. INITIAL COST FACTOR**	SPECIAL FEATURES
		FULL	PRO RATA			
Premium quality, valve regulated, recombinant, lead calcium	20	1	19	1 year	2.5	Spill proof.
Standard quality, valve regulated, recombinant, lead calcium	10	1	9	1 year	1.0	Spill proof.
Nickel cadmium, flooded	25	5	15	3 years	4.0	Can operate in high ambient temperatures. Can be completely discharged without damage.
Lead calcium, flooded	20	1	9	6 months	2.5	-

*Life expectancy and warranty data apply to installations where batteries are considered to be in a "float-service"

application. Use the data only as a general guide because UPS batteries are typically considered to be in a separate service application category that accounts for the numerous discharges of varying duration they experience.

**Cost includes an allowance for space requirements and environmental control.

1. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
   a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

   OR

   Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.
   a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

   OR

   Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers mounted on three-tier, **as directed**, acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.
2. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

H. Controls And Indications
1. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
2. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
3. Indications: Labeled LED **OR** Plain-language messages on a digital LCD or LED, **as directed**.
   a. Quantitative indications shall include the following:
      1) Input voltage, each phase, line to line.
      2) Input current, each phase, line to line.
      3) Bypass input voltage, each phase, line to line.
      4) Bypass input frequency.
      5) System output voltage, each phase, line to line.
      6) System output current, each phase.
      7) System output frequency.
      8) DC bus voltage.
      9) Battery current and direction (charge/discharge).
      10) Elapsed time discharging battery.
   b. Basic status condition indications shall include the following:
      1) Normal operation.
      2) Load-on bypass.
      3) Load-on battery.
      4) Inverter off.
      5) Alarm condition.
   c. Alarm indications shall include the following:
      1) Bypass ac input overvoltage or undervoltage.
      2) Bypass ac input overfrequency or underfrequency.
      3) Bypass ac input and inverter out of synchronization.
      4) Bypass ac input wrong-phase rotation.
      5) Bypass ac input single-phase condition.
      6) Bypass ac input filter fuse blown.
      7) Internal frequency standard in use.
      8) Battery system alarm.
      9) Control power failure.
      10) Fan failure.

11) UPS overload.
12) Battery-charging control faulty.
13) Input overvoltage or undervoltage.
14) Input transformer overtemperature.
15) Input circuit breaker tripped.
16) Input wrong-phase rotation.
17) Input single-phase condition.
18) Approaching end of battery operation.
19) Battery undervoltage shutdown.
20) Maximum battery voltage.
21) Inverter fuse blown.
22) Inverter transformer overtemperature.
23) Inverter overtemperature.
24) Static bypass transfer switch overtemperature.
25) Inverter power supply fault.
26) Inverter transistors out of saturation.
27) Identification of faulty inverter section/leg.
28) Inverter output overvoltage or undervoltage.
29) UPS overload shutdown.
30) Inverter current sensor fault.
31) Inverter output contactor open.
32) Inverter current limit.

d. Controls shall include the following:
1) Inverter on-off.
2) UPS start.
3) Battery test.
4) Alarm silence/reset.
5) Output-voltage adjustment.

4. Dry-form "C" contacts shall be available for remote indication of the following conditions:
a. UPS on battery.
b. UPS on-line.
c. UPS load-on bypass.
d. UPS in alarm condition.
e. UPS off (maintenance bypass closed).

5. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

I. Maintenance Bypass/Isolation Switch
1. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
a. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
b. Switch shall electrically isolate other UPS components to permit safe servicing.
2. Comply with NEMA PB 2 and UL 891.
3. Switch Rating: Continuous duty at rated full UPS load current.
4. Mounting Provisions: Internal to system cabinet **OR** Separate wall- or floor-mounted unit, **as directed**.
5. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

J. Output Isolation Transformer

1. Description: Shielded unit **OR** Unit, **as directed**, with low forward transfer impedance up to 3 kHz, minimum. Include the following features:
   a. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 4 **OR** 9 **OR** 13 **OR** 20, **as directed**.
   b. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
   c. Regulation: 5 percent, maximum, at rated nonlinear load current.
   d. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
   e. Electrostatic Shielding of Windings: Independent for each winding.
   f. Coil Leads: Physically arranged for minimum interlead capacitance.
   g. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
   h. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHz.

K. Output Distribution Section
1. Panelboards: Comply with Division 16 Section "Panelboards" except provide assembly integral to UPS cabinet.

L. Monitoring By Remote Status And Alarm Panel
1. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
   a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

M. Monitoring By Remote Computer
1. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
   a. Connectors and network interface units or modems for data transmission via RS-232 link.
   b. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
   c. Software and Hardware: Compatible with that specified in Division 16 Section "Electrical Power Monitoring And Control".

N. Basic Battery Monitoring
1. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
2. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.
3. Annunciation of Alarms: At UPS control panel.

O. Additional Battery Monitoring
1. Monitoring features and components shall include the following:
   a. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
   b. Connections for data transmission via RS-232 link, network interface and, **as directed**, modem and, **as directed**, external signal wiring to computer **OR** electrical power monitoring and control equipment, **as directed**. External signal wiring and computer are not specified in this Section.
   c. PC-based software designed to store and analyze battery data. Software compiles reports on individual-cell parameters and total battery performance trends, and provides data for scheduling and prioritizing battery maintenance.

2. Performance: Automatically measures and electronically records the following parameters on a routine schedule and during battery discharge events. During discharge events, records measurements timed to nearest second; includes measurements of the following parameters:
   a. Total battery voltage and ambient temperature.
   b. Individual-cell voltage, impedance, and temperature. During battery-discharging events such as utility outages, measures battery and cell voltages timed to nearest second.
   c. Individual-cell electrolyte levels.

P. Battery-Cycle Warranty Monitoring
1. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.
2. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.
3. Additional monitoring functions and features shall include the following:
   a. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
   b. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
   c. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
   d. Alarm Contacts: Arranged to initiate local **OR** remote, **as directed**, alarm for battery discharge events **OR** abnormal temperature **OR** abnormal battery voltage or temperature, **as directed**.
   e. Memory: Stores recorded data in nonvolatile electronic memory.
   f. RS-232 Port: Permits downloading of data to a portable PC.
   g. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

Q. Source Quality Control
1. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation **OR** simulated battery testing, **as directed**. Include the following:
   a. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
   b. Full-load test.
   c. Transient-load response test.
   d. Overload test.
   e. Power failure test.
2. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.
3. Report test results. Include the following data:
   a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
   b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
   c. List of instruments and equipment used in factory tests.

1.3 EXECUTION

A. Installation
1. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to supported equipment.

2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
3. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.

B. Grounding
1. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.

C. Identification
1. Identify components and wiring according to Division 16 Section "Electrical Identification".
a. Identify each battery cell individually.

D. Battery Equalization
1. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

E. Field Quality Control
1. Perform tests and inspections.
a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
a. Comply with manufacturer's written instructions.
b. Inspect interiors of enclosures, including the following:
1) Integrity of mechanical and electrical connections.
2) Component type and labeling verification.
3) Ratings of installed components.
c. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
d. Test manual and automatic operational features and system protective and alarm functions.
e. Test communication of status and alarms to remote monitoring equipment.
f. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
1) Simulate malfunctions to verify protective device operation.
2) Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
3) Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
4) Test output voltage under specified transient-load conditions.
5) Test efficiency at 50, 75, and 100 percent of rated loads.
6) Test remote status and alarm panel functions.
7) Test battery-monitoring system functions.
3. Seismic-restraint tests and inspections shall include the following:
a. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.
b. Test mounting and anchorage devices according to requirements in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

4. The UPS system will be considered defective if it does not pass tests and inspections.
5. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
6. Prepare test and inspection reports.

F. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 16265

SECTION 16265a - CENTRAL BATTERY INVERTERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for central battery inverters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes slow-transfer, fast-transfer, and UPS central battery inverters with the following features:
   a. Output distribution section.
   b. Internal maintenance bypass/isolation switch.
   c. External maintenance bypass/isolation switch.
   d. Multiple output voltages.
   e. Emergency-only circuits.
   f. Remote monitoring provisions.

C. Definitions
1. LCD: Liquid-crystal display.
2. LED: Light-emitting diode.
3. THD: Total harmonic distortion.
4. UPS: Uninterruptible power supply.

D. Submittals
1. Product Data: For the following:
   a. Electrical ratings, including the following:
      1) Capacity to provide power during failure of normal ac.
      2) Inverter voltage regulation and THD of output current.
      3) Rectifier data.
      4) Transfer time of transfer switch.
      5) Data for specified optional features.
   b. Transfer switch.
   c. Inverter.
   d. Battery charger.
   e. Batteries.
   f. Battery monitoring.
   g. Battery-cycle warranty monitor.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
   a. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
   b. Elevation and details of control and indication displays.
   c. Output distribution section.
3. Manufacturer Seismic Qualification Certification: Submit certification that central battery inverter equipment will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Operation and Maintenance Data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Central Battery Inverter System: UL 924 and UL 1778, **as directed**, listed.
3. Comply with NFPA 70 and NFPA 101.

F. Delivery, Storage, And Handling
1. Deliver equipment in fully enclosed vehicles.
2. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
   a. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
      1) Premium, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
         a) Full Warranty: One year.
         b) Pro Rata: 19 years.
      2) Standard, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
         a) Full Warranty: One year.
         b) Pro Rata: Nine years.
      3) Nickel-Cadmium, Wet-Cell Batteries:
         a) Full Warranty: Five years.
         b) Pro Rata: 15 years.
      4) Lead-Calcium, Wet-Cell Batteries:
         a) Full Warranty: One year.
         b) Pro Rata: Nine years.
      5) Lead-Antimony, Wet-Cell Batteries:
         a) Full Warranty: One year.
         b) Pro Rata: Nine years.

1.2 PRODUCTS

A. Inverter Performance Requirements
1. Slow-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use an electromechanical switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.
   a. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
2. Fast-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use a solid-state switch to transfer loads. Transfer in 0.004 second or less from normal supply to battery-inverter supply.
   a. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
3. UPS-Type Central Battery Inverters: Continuously provide ac power to connected electrical system.
   a. Automatic Operation:

1) Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier-charger and inverter, with battery connected in parallel with rectifier-charger output.
2) Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
3) If normal power fails, battery continues supply-regulated ac power through the inverter to the load without switching or disturbance.
4) When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier-charger then supplies power to the load through the inverter and simultaneously recharges battery.
5) If battery becomes discharged and normal supply is available, rectifier-charger charges battery. When battery is fully charged, rectifier-charger automatically shifts to float-charge mode.
6) If any element of central battery inverter system fails and power is available at normal supply terminals of system, static bypass transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
7) If a fault occurs in system supplied by central battery inverter and current flows in excess of the overload rating of central battery inverter system, static bypass transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
8) When fault has cleared, static bypass transfer switch returns the load to central battery inverter system.
9) If battery is disconnected, central battery inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.

b. Manual Operation:
1) Turning inverter off causes static bypass transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.
2) Turning inverter on causes static bypass transfer switch to transfer the load to inverter.

4. Maximum Acoustical Noise: <**Insert value**> dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured 39 inches (990 mm) from nearest surface of component enclosure.

B. Service Conditions
1. Environmental Conditions: Inverter system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
a. Ambient Temperature for Electronic Components: 32 to 98 deg F (0 to 37 deg C).
b. Relative Humidity: 0 to 95 percent, noncondensing.
c. Altitude: Sea level to 4000 feet (1220 m).

C. Inverters
1. Description: Solid-state type, with the following operational features:
a. Automatically regulate output voltage to within plus or minus 5 percent.
b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
c. Output Voltage Waveform of Unit: Sine wave with maximum 10 percent THD throughout battery operating-voltage range, from no load to full load.
1) THD may not exceed 5 percent when serving a resistive load of 100 percent of unit rating.
d. Output Protection: Current-limiting and short-circuit protection.
OR
Output Protection: Ferroresonant transformer to provide inherent overload and short-circuit protection.

e. Surge Protection: Panelboard **OR** Auxiliary panel, **as directed**, suppressors specified in Division 16 Section "Transient Voltage Suppression".
f. Overload Capability: 125 percent for 10 minutes; 150 percent surge.
g. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.

D. Battery Charger
1. Description: Solid-state, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes.

E. Batteries
1. Description: Premium, valve-regulated, recombinant, lead-calcium **OR** Standard, valve-regulated, recombinant, lead-calcium **OR** Nickel-cadmium, wet-cell **OR** Lead-calcium, wet-cell **OR** Lead-antimony, wet-cell, **as directed**, batteries.
a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.

F. Enclosures
1. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

G. Seismic Requirements
1. Central battery inverter assemblies, subassemblies, components, fastenings, supports, and mounting and anchorage devices shall be designed and fabricated to withstand seismic forces, **as directed**. The term "withstand" is defined in the "Manufacturer Seismic Qualification Certification" Paragraph in Part 1.1 "Submittals" Article.

H. Control And Indication
1. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.
2. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.
3. Indications: Labeled LED **OR** Plain-language messages on a digital LCD or LED, **as directed**.
a. Quantitative Indications:
1) Input voltage, each phase, line to line.
2) Input current, each phase, line to line.
3) System output voltage, each phase, line to line.
4) System output current, each phase.
5) System output frequency.
6) DC bus voltage.
7) Battery current and direction (charge/discharge).
8) Elapsed time-discharging battery.
b. Basic Status Condition Indications:
1) Normal operation.
2) Load-on bypass.
3) Load-on battery.
4) Inverter off.
5) Alarm condition exists.
c. Alarm Indications:
1) Battery system alarm.
2) Control power failure.
3) Fan failure.
4) Overload.
5) Battery-charging control faulty.

6) Input overvoltage or undervoltage.
7) Approaching end of battery operation.
8) Battery undervoltage shutdown.
9) Inverter fuse blown.
10) Inverter transformer overtemperature.
11) Inverter overtemperature.
12) Static bypass transfer switch overtemperature.
13) Inverter power supply fault.
14) Inverter output overvoltage or undervoltage.
15) System overload shutdown.
16) Inverter output contactor open.
17) Inverter current limit.

d. Controls:
1) Inverter on-off.
2) Start.
3) Battery test.
4) Alarm silence/reset.
5) Output-voltage adjustment.

4. Dry-form "C" contacts shall be available for remote indication of the following conditions:
a. Inverter on battery.
b. Inverter on-line.
c. Inverter load-on bypass.
d. Inverter in alarm condition.
e. Inverter off (maintenance bypass closed).

5. Include the following minimum array:
a. Ready, normal-power on light.
b. Charge light.
c. Inverter supply load light.
d. Battery voltmeter.
e. AC output voltmeter with minimum accuracy of 2 percent of full scale.
f. Load ammeter.
g. Test switch to simulate ac failure.

6. Enclosure: Steel, with hinged lockable doors, suitable for wall **OR** floor, **as directed**, mounting. Manufacturer's standard corrosion-resistant finish.

I. Optional Features

1. Multiple Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.
2. Emergency-Only Circuits: Automatically energize only when normal supply has failed. Disconnect emergency-only circuits when normal power is restored.
3. Maintenance Bypass/Isolation Switch: Load is supplied, bypassing central battery inverter system. Normal supply, electromechanical transfer switch, and system load terminals are completely disconnected from external circuits.
4. Maintenance Bypass/Isolation Switch: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in bypass mode. Switch provides manual selection among the following three conditions without interrupting supply to the load during switching:
a. Full Isolation: Load is supplied, bypassing central battery inverter system. Normal ac input circuit, static bypass transfer switch, and central battery inverter load terminals are completely disconnected from external circuits.
b. Maintenance Bypass: Load is supplied, bypassing central battery inverter system. Central battery inverter ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
c. Normal: Normal central battery inverter ac supply terminals are energized and the load is supplied either through static bypass transfer switch and central battery inverter rectifier-charger and inverter or through battery and inverter.

J. Output Distribution Section
   1. Panelboard: Comply with Division 16 Section "Panelboards" except provide assembly integral to equipment cabinet.

K. System Monitoring And Alarms
   1. Remote Status and Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
      a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
   2. Provisions for Remote Computer Monitoring: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in Part 1.2 "Control and Indication" Article. Remote computer and connecting signal wiring will be provided by Owner. Include the following features:
      a. Connectors and network interface units or modems for data transmission via RS-232 link.
      b. Software shall be designed to control and monitor inverter system functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of reports. Include capability for storage and analysis of power-line transient records. Software shall be compatible with requirements in Division 16 Section "Electrical Power Monitoring And Control" and the operating system and configuration of Owner-furnished computers.
   3. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
      a. Annunciation of Alarms: At inverter system control panel.
   4. Battery-Cycle Warranty Monitoring: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring charge-discharge cycle history of batteries covered by cycle-life warranty.
      a. Basic Functional Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral LCD.
      b. Additional monitoring functions and features shall include the following:
         1) Measuring and recording of total voltage at battery terminals; providing alarm for excursions outside proper float voltage level.
         2) Monitoring of ambient temperature at battery and initiating an alarm if temperature deviates from normally acceptable range.
         3) Keypad on device front panel provides access to monitored data using front panel display.
         4) Alarm contacts arranged to provide local **OR** remote, **as directed**, alarm for battery discharge events **OR** abnormal temperature **OR** abnormal battery voltage or temperature, **as directed**.
         5) Memory device to store recorded data in nonvolatile electronic memory.
         6) RS-232 port to permit downloading of data to a portable personal computer.
         7) Modem to make measurements and recorded data accessible to remote personal computer via telephone line. Computer will be provided by Owner.

L. Source Quality Control
   1. Factory test complete inverter system, including battery, before shipment. Include the following:
      a. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
      b. Full-load test.
      c. Transient-load response test.
      d. Overload test.
      e. Power failure test.
   2. Observation of Test: Give 14 days' advance notice of tests and provide access for Owner's representative to observe tests at Owner's option.
   3. Report test results. Include the following data:

a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
c. List of instruments and equipment used in factory tests.

1.3 EXECUTION

A. Installation
1. Install system components on floor **OR** concrete base, **as directed**, and attach by bolting.
a. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section "Vibration And Seismic Controls For Electrical Systems" for seismic-restraint requirements.
b. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 16 Section "Hangers And Supports For Electrical Systems".
c. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
e. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

B. Connections
1. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
2. Ground equipment according to Division 16 Section "Grounding And Bonding".
a. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.
3. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Identification
1. Identify equipment and components according to Division 16 Section "Electrical Identification".

D. Field Quality Control
1. Perform tests and inspections and prepare test reports.
a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
a. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
b. Test manual and automatic operational features and system protective and alarm functions.
c. Test communication of status and alarms to remote monitoring equipment.
d. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters.
e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.

E. Startup Service
   1. Engage a factory-authorized service representative to perform startup service.
   2. Verify that central battery inverter is installed and connected according to the Contract Documents.
   3. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 15.
   4. Complete installation and startup checks according to manufacturer's written instructions.

F. Adjusting And Cleaning
   1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
   2. Install new filters in each equipment cabinet within 14 days from date of Substantial Completion.

END OF SECTION 16265a

SECTION 16320 - SWITCHGEAR

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for switchgear. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1000 V and less for use in ac systems.

C. Definitions
1. ATS: Acceptance Testing Service.
2. GFCI: Ground-fault circuit interrupter.

D. Submittals
1. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: For each type of switchgear and related equipment.
   a. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
   b. Wiring Diagrams: Power, signal, and control wiring.
3. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
4. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.
5. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
6. Field quality-control test reports.
7. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.
8. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. Include the following:
   a. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
   b. Time-current curves, including selectable ranges for each type of overcurrent protective device.

E. Quality Assurance
1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   a. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with NFPA 70.

F. Delivery, Storage, And Handling
1. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.
2. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
3. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

G. Project Conditions
1. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
2. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
4. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
   a. Ambient Temperature: Not exceeding 40 deg C.
   b. Altitude: Not exceeding 6600 feet (2010 m).

1.2 PRODUCTS

A. Ratings
1. Nominal System Voltage: 480 V, 3 wire **OR** 480/277 V, 4 wire **OR** 240 V, 3 wire **OR** 208/120 V, 4 wire, **as directed,** 60 Hz.
2. Main-Bus Continuous: 4000 **OR** 3200 **OR** 2000 **OR** 1600, **as directed,** A.
3. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

B. Fabrication
1. Factory assembled and tested and complying with IEEE C37.20.1.
2. Indoor Enclosure Material: Steel.
3. Outdoor Enclosure Material: Galvanized steel.
4. Outdoor Enclosure Fabrication Requirements: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating; and each compartment equipped with the following features:
   a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h), **as directed**, wind.
   b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
   c. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
   d. Hinged front door with padlocking provisions.
   e. Interior light with switch.
   f. Weatherproof duplex receptacle.

g. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
h. Aisle access doors with outside padlocking provisions and interior panic latches.
i. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
j. Vaporproof fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
k. GFCI duplex receptacles, a minimum of two, located in aisle.
l. Aisle ventilation louvers equipped with insect and rodent screen and filter and arranged to permit air circulation while excluding insects, rodents, and exterior dust.

5. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.
6. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.
7. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
8. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
9. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear.
10. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
    a. Utility metering compartment that complies with utility company requirements.
    b. Bus transition sections.
    c. Incoming-line pull sections.
    d. Hinged front panels for access to metering, accessory, and blank compartments.
    e. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.
        1) Set pull box back from front to clear circuit-breaker lifting mechanism.
        2) Bottom: Insulating, fire-resistant material with separate holes for cable drops into switchgear.
        3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.
11. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
    a. Main Phase Bus: Uniform capacity the entire length of assembly.
    b. Neutral Bus: 50 **OR** 100, **as directed,** percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
    c. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
    d. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.
       OR
       Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.
       OR
       Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
    e. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
    f. Use copper for connecting circuit-breaker line to copper bus.
    g. Contact Surfaces of Buses: Silver plated.
    h. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

i. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).
j. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
k. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
l. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.
m. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
n. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
1) Sprayed Insulation Thickness: 3 mils (0.08 mm), minimum.
2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

C. Components
1. Instrument Transformers: Comply with IEEE C57.13.
a. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
b. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.
2. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
a. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
b. Switch-selectable digital display of the following:
1) Phase Currents, Each Phase: Plus or minus 1 percent.
2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
4) Three-Phase Real Power: Plus or minus 2 percent.
5) Three-Phase Reactive Power: Plus or minus 2 percent.
6) Power Factor: Plus or minus 2 percent.
7) Frequency: Plus or minus 0.5 percent.
8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
c. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Analog Instruments: Rectangular, 4-1/2-inch (115-mm) square, accurate within 1 percent, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment, complying with ANSI C39.1.
a. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
b. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
c. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
d. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
e. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
f. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, 3 phase, 3 wire; with 3 elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.

g. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
   1) Operation: Meter counts and records a succession of pulses entering two channels.
   2) Housing: Drawout, back-connected case arranged for semiflush mounting.

4. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
5. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and NEMA LA 1.
   a. Install in cable termination compartments and connect in each phase of circuit.
   b. Coordinate rating with circuit voltage.
6. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
7. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.
8. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:
   a. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
   b. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
      1) Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.
      2) Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
   c. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.
   d. Fuses are specified in Division 16 Section "Fuses".
9. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
   a. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
   b. Conductors sized according to NFPA 70 for duty required.

D. Circuit Breakers
1. Description: Comply with IEEE C37.13.
2. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
   a. Normal Closing Speed: Independent of both control and operator.
   b. Slow Closing Speed: Optional with operator for inspection and adjustment.
   c. Stored-Energy Mechanism: Manually charged **OR** Electrically charged, with optional manual charging, **as directed**.
   d. Operation counter.
4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
   a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
   b. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
   c. Field-adjustable, time-current characteristics.
   d. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
   e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
   f. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I^2t operation.

g. Pickup Points: Five minimum, for instantaneous-trip functions.
h. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
   1) Three-wire circuit or system.
   2) Four-wire circuit or system.
   3) Four-wire, double-ended substation.
i. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

5. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
6. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
   a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
   b. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
      1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
      2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
7. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
9. Operating Handle: One for each circuit breaker capable of manual operation.
10. Electric Close Button: One for each electrically operated circuit breaker.
11. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
12. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
13. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage **OR** Adjustable time-delay and pickup voltage, **as directed**.
14. Shunt-Trip Devices: Where indicated.
15. Fused Circuit Breakers: Circuit breaker and fuse combinations complying with requirements for circuit breakers and trip devices and with the following:
   a. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
   b. Circuit Breakers with Frame Size 1600 A and Smaller: Fuses on line side of associated circuit breaker, on a common drawout mounting, arranged so fuses are accessible only when circuit breaker is in disconnected position.
   c. Circuit Breakers with Frame Sizes More Than 1600 A: Fuses and circuit breakers may be installed in separate compartments on separate drawout mountings. Fuse drawout element is interlocked with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in open position.
   d. Open-Fuse Trip Device: Positive means of tripping and holding circuit breaker in open position when a fuse opens. Open-fuse status is indicated at front of circuit breaker or fuse drawout element.

16. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

E. Accessories
1. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
   a. Racking handle to manually move circuit breaker between connected and disconnected positions.
   b. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
   c. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
2. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
3. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
4. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
5. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

F. Identification
1. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
   a. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
   b. Medium: Painted graphics, as selected by Architect.
   c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
2. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
   a. Frame size of each circuit breaker.
   b. Trip rating for each circuit breaker.
   c. Conduit and wire size for each feeder.

1.3 EXECUTION

A. Installation
1. Comply with applicable portions of NECA 400.
2. Anchor switchgear assembly to 4-inch (100-mm), channel-iron floor sill embedded in floor **OR** concrete base, **as directed,** and attach by bolting.
   a. Sills: Select to suit switchgear; level and grout flush into floor **OR** concrete base, **as directed**.
   b. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 16 Section "Hangers And Supports For Electrical Systems" for seismic-restraint requirements.
   c. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 3 inches (75 mm) in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 16 Section "Hangers And Supports For Electrical Systems".
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

B. Identification
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification".
   2. Diagram and Instructions:
      a. Frame and mount under clear acrylic plastic on the front of switchgear.
         1) Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
         2) System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
      b. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

C. Connections
   1. Ground equipment according to Division 16 Section "Grounding And Bonding".
   2. Connect wiring according to Division 16 Section "Conductors And Cables".

D. Field Quality Control
   1. Prepare for acceptance tests as follows:
      a. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
      b. Test continuity of each circuit.
   2. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
      a. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
      b. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 15.
      c. Complete installation and startup checks according to manufacturer's written instructions.
      d. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
      e. Report results in writing.
   3. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
      a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
         1) Switchgear.
         2) Circuit breakers.
         3) Protective relays.
         4) Instrument transformers.
         5) Metering and instrumentation.
         6) Ground-fault systems.
         7) Battery systems.
         8) Surge arresters.
         9) Capacitors.
      b. Remove and replace malfunctioning units and retest as specified above.
   4. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
      a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
      b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

c. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

E. Adjusting
1. Set field-adjustable, protective-relay trip characteristics according to results in Division 16 Section "Overcurrent Protective Device Coordination".
2. Set field-adjustable, protective-relay trip characteristics.

F. Cleaning
1. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

G. Protection
1. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

END OF SECTION 16320

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SECTION 16330 - MEDIUM-VOLTAGE TRANSFORMERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for medium-voltage transformers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following types of transformers with medium-voltage primaries:
   a. Liquid-filled distribution and power transformers.
   b. Dry-type distribution and power transformers.
   c. Pad-mounted, liquid-filled transformers.

C. Definitions
1. NETA ATS: Acceptance Testing Specification.

D. Submittals
1. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
2. Shop Drawings: Diagram power signal and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Field quality-control test reports.
5. Follow-up service reports.
6. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2.
3. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.
4. Comply with NFPA 70.

F. Delivery, Storage, And Handling
1. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

G. Project Conditions
1. Service Conditions: IEEE C37.121, usual service conditions except for the following:
   a. Exposure to significant solar radiation.
   b. Altitudes above 3300 feet (1000 m).
   c. Exposure to fumes, vapors, or dust.
   d. Exposure to explosive environments.
   e. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
   f. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
   g. Exposure to excessively high or low temperatures.

h. Unusual transportation or storage conditions.
i. Unusual grounding-resistance conditions.
j. Unusual space limitations.

1.2 PRODUCTS

A. Liquid-Filled Distribution And Power Transformers
1. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding transformers.
2. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.
OR
Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
OR
Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
OR
Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
3. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kilovolt-ampere output, at 65 deg C temperature rise, without decreasing rated transformer life.
OR
Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
4. Basic Impulse Level: Comply with UL 1062.
OR
Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed** kV.
5. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
OR
Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
6. Cooling System: Class OA, self-cooled **OR** OA/FA, self-cooled, and with forced-air-cooled rating **OR** OA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, **as directed**. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
7. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
8. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:
a. Liquid-level gage.
b. Pressure-vacuum gage.
c. Liquid temperature indicator.
d. Drain and filter valves.
e. Pressure relief device.

B. Dry-Type Distribution And Power Transformers

1. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.50 for dry-type transformers rated up to 500 kVA, ANSI C57.12.51 for dry-type transformers rated 501 kVA and larger, or ANSI C57.12.52 for sealed dry-type transformers rated 501 kVA and larger, UL 1562 listed and labeled, dry-type, 2-winding transformers.
   a. Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
   b. Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, vacuum-pressure impregnated and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
2. Primary Connection: Air terminal compartment with removable **OR** hinged, **as directed,** door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
   OR
   Primary Connection: Transition terminal compartment with connection pattern to match switchgear.
3. Secondary Connection: Air terminal compartment with removable **OR** hinged, **as directed,** door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
   OR
   Secondary Connection: Transition terminal compartment with connection pattern to match switchgear **OR** bus duct, **as directed**.
4. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.
5. Insulation Temperature Rise: 80 **OR** 115 **OR** 150, **as directed,** deg C, maximum rise above 40 deg C.
6. Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed,** kV.
7. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.
   OR
   Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.
8. Cooling System: Class AA, self-cooled **OR** AA/FA, self-cooled, and with forced-air-cooled rating **OR** AA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, **as directed**, complying with IEEE C57.12.01.
   a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
   b. Include mounting provision for fans.
9. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
10. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

C. Pad-Mounted, Liquid-Filled Transformers

1. Description: ANSI C57.12.13, ANSI C57.12.26 for pad-mounted transformers with dead-front, separable, insulated, high-voltage, load-break cable connectors, IEEE C57.12.00 IEEE C57.12.22 for pad-mounted transformers with live-front high-voltage bushings pad-mounted, 2-winding transformers. Stainless-steel tank base and cabinet, **OR** cabinet, and sills, **as directed**.
2. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.
   OR
   Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

OR

Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

OR

Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.

3. Insulation Temperature Rise: 55 **OR** 65, **as directed,** deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.
4. Basic Impulse Level: 30 **OR** 60 **OR** 95, **as directed,** kV.
5. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
6. High-Voltage Switch: 200 **OR** 300 **OR** 400, **as directed,** A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for radial feed with 3-phase, 2-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.

   OR

   High-Voltage Switch: 200 **OR** 300 **OR** 400, **as directed,** A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for loop feed with 3-phase, 4-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.
7. Primary Fuses: 150-kV fuse assembly with fuses complying with IEEE C37.47. Rating of current-limiting fuses shall be 50-kA RMS at specified system voltage.
   a. Current-limiting type in dry-fuse holder wells, mechanically interlocked with liquid-immersed switch in transformer tank to prevent disconnect under load.
   b. Internal liquid-immersed cartridge fuses.
   c. Bay-O-Net liquid-immersed fuses that are externally replaceable without opening transformer tank.
   d. Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses. Bay-O-Net fuses shall be externally replaceable without opening transformer tank.
   e. Bay-O-Net liquid-immersed current-limiting fuses that are externally replaceable without opening transformer tank.
8. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. Transformers shall have three arresters for radial-feed **OR** three arresters for loop-feed **OR** six arresters for loop-feed, **as directed,** circuits.
9. High-Voltage Terminations and Equipment: Live front with externally clamped porcelain bushings and cable connectors suitable for terminating primary cable.

   OR

   High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:
   a. Bushing-Well Inserts: One for each high-voltage bushing well.
   b. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
   c. Parking Stands: One for each high-voltage bushing well.
   d. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.
10. Accessories:
    a. Drain Valve: 1 inch (25 mm), with sampling device.
    b. Dial-type thermometer.
    c. Liquid-level gage.
    d. Pressure-vacuum gage.
    e. Pressure Relief Device: Self-sealing with an indicator.
    f. Mounting provisions for low-voltage current transformers.

g. Mounting provisions for low-voltage potential transformers.
h. Busway terminal connection at low-voltage compartment.
i. Alarm contacts for gages and thermometer listed above.

D. Identification Devices
1. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 16 Section "Electrical Identification".

E. Source Quality Control
1. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.50 for ventilated dry-type distribution transformers 1 to 500 kVA, single phase, and 15 to 500 kVA, 3 phase, with high voltage 601 to 34,500 V and low voltage 208Y/120 to 4160 V; ANSI C57.12.51 for ventilated dry-type power transformers 501 kVA and larger, 3 phase, with high voltage 601 to 34,500 V and low voltage 208Y/120 to 4160 V; IEEE C57.12.90 for liquid-filled transformers; and IEEE C57.12.91 for dry-type distribution and power transformers.
2. Factory Tests: Perform the following factory-certified tests on each transformer:
a. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
b. Ratios on rated-voltage connection and on tap extreme connections.
c. Polarity and phase relation on rated-voltage connection.
d. No-load loss at rated voltage on rated-voltage connection.
e. Excitation current at rated voltage on rated-voltage connection.
f. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
g. Applied potential.
h. Induced potential.
i. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
1) Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

1.3 EXECUTION

A. Installation
1. Install transformers on concrete bases.
a. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 16 Section "Hangers And Supports For Electrical Systems".
b. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
c. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
d. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
e. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
f. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
g. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.

2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

B. Identification
1. Identify field-installed wiring and components and provide warning signs as specified in Division 16 Section "Electrical Identification", **as directed.**

C. Connections
1. Ground equipment according to Division 16 Section "Grounding And Bonding".
2. Connect wiring according to Division 16 Section "Conductors And Cables".

D. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
   a. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
   b. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
   c. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
   d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.
3. Test Reports: Prepare written reports to record the following:
   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

E. Follow-Up Service
1. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:
   a. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
   b. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
      1) Adjust transformer taps.
      2) Prepare written request for voltage adjustment by electric utility.
   c. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
   d. Report: Prepare written report covering monitoring and corrective actions performed.
2. Infrared Scanning: Perform as specified in Division 16 Section "Medium-voltage Switchgear".

END OF SECTION 16330

SECTION 16330a - OVERHEAD ELECTRICAL DISTRIBUTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for overhead electrical distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Conductors, connectors, and splices.
b. Poles and crossarms.
c. Hardware and accessories.
d. Surge arresters.
e. Cutouts, switches, and fuses.
f. Pole-mounted distribution transformers.
g. Primary metering equipment.

C. Definitions
1. BIL: Basic impulse level, stated in kilovolts.
2. RUS: Department of Agriculture, Rural Utilities Service.
3. Sag: The distance measured vertically from a conductor to the straight line joining its two points of support, measured at the midpoint of the span, unless otherwise indicated.
a. Final Sag: The sag of a conductor under specified conditions of loading and temperature applied after it has been subjected, for an appreciable period, to the loading prescribed for the loading district in which it is situated, or equivalent loading, and the loading removed. Final sag includes the effect of inelastic deformation (creep).
b. Initial Unloaded Sag: The sag of a conductor before the application of an external load.
4. Secondary: Conductors and components for circuits operating at the utilization voltage of 600 V or less.
5. Service: Set of insulated conductors extending from a pole to the metering point or service entrance connection at the location of utilization of electricity.

D. Submittals
1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Qualification Data: For qualified manufacturer **OR** testing agency, **as directed**.
3. Material Certificates: For the following items, from manufacturers:
a. Wood poles.
b. Concrete poles.
c. Wood crossarms.
4. Listing Documentation: Indicate that products comply with RUS listing requirements specified in "Quality Assurance" Article.
a. Time-Current Coordination Curves: Illustrate optimum coordination of protective devices involved in the Work of this Section.
b. Source quality-control test reports.
5. Field quality-control reports.
6. Operation and Maintenance Data: For switches **OR** transformers, **as directed**, to include in emergency, operation, and maintenance manuals.
7. Survey records for locations of pole, anchors, and other features for inclusion in Project Record Documents.

E. Quality Assurance
1. Concrete Pole Manufacturer Qualifications: Certified by PCI as a qualified manufacturer of concrete utility poles of type and size indicated for this Project.
2. Inspection Agency Qualifications for Pole and Crossarm Inspection: An independent agency, acceptable to authorities having jurisdiction, qualified to conduct inspections indicated.
3. Testing Agency Qualifications: Member company of NETA or an NRTL.
4. Testing Agency's Field Supervisor: Currently certified by NETA or an NRTL.
5. Treatment Technician Qualifications for Field Treatment of Wood Poles and Crossarms: Certified by authorities having jurisdiction over environmental protection at the location of Project for field application of chemicals required.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
7. Overhead-Line Components, Devices, and Accessories: Currently listed in RUS Informational Publication 202-1 without restriction for the intended application.
8. Comply with IEEE C2 **OR** CPUC General Order 95, **as directed**, except where stricter requirements are indicated or where local requirements that are stricter apply.
9. Strength of Line and Line Components Selected by Contractor: Provide grades of construction and strength required by IEEE C2 for conditions encountered at Project site for heavy **OR** medium **OR** light, **as directed**, line loading unless otherwise indicated.

F. Delivery, Storage, And Handling
1. Wood Pole Storage and Handling: Comply with ATIS O5.1. Do not use pointed handling tools capable of producing indentations greater than 1 inch (25 mm).

G. Project Conditions
1. Interruption of Existing Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of service.
   b. Do not proceed with interruption of service without Owner's written permission.

H. Coordination
1. Coordinate with utility supplying electricity to lines specified in this Section, and make final connections **OR** arrangements for final connections by utility, **as directed**.
2. Coordinate with those responsible for voice **OR** data **OR** video, **as directed**, systems that will have cables supported by poles installed according to this Section.

1.2 PRODUCTS

A. Conductors, Connectors, And Splices
1. Conductor Type AAC: Bare **OR** Bare and covered, **as directed**, all-aluminum, Alloy 1350-H19, complying with ASTM B 230/B 230M and ASTM B 231/B 231M.
   OR
   Conductor Type AAAC: Bare **OR** Bare and covered, **as directed**, all-aluminum-alloy, Alloy 6201-T81, complying with ASTM B 398/B 398M and ASTM B 399/B 399M.
   OR
   Conductor Type ACSR: Bare **OR** Bare and covered, **as directed**, aluminum conductor, steel reinforced, complying with ASTM B 232/B 232M.
   OR
   Conductor Type CU: Bare **OR** Bare and covered, **as directed**, hard-drawn copper, complying with ASTM B 1 and ASTM B 8.
2. Conductor Covering: UV resistant, complying with ICEA-S-70-547. HDPE **OR** XLP, **as directed**, 150 mils (3.81 mm) thick.

3. Self-Supported, Multiconductor, Insulated Medium-Voltage Wiring: Factory-assembled, messenger-supported type, listed under UL 1072 as sunlight-resistant Type MV cable for cable tray use.
   a. Conductors: Aluminum, Alloy 1350, complying with ASTM B 230/B 230M and ASTM B 231/B 231M **OR** Hard-drawn copper, complying with ASTM B 1 and ASTM B 8, **as directed**; stranded for No. 2 AWG and larger.
   b. Conductor Insulation: XLP, complying with NEMA WC 70/ICEA S-95-658 **OR** EPR, complying with NEMA WC 70/ICEA S-95-658, **as directed**.
   c. Insulation Level: 100 **OR** 133, **as directed**, percent of rated circuit line-to-line voltage.
   d. Conductor Shield: Extruded, nonconducting, thermoset material, complying with NEMA WC 70/ICEA S-95-658; 18-mil (0.046-mm) minimum thickness.
   e. Insulation Shield: Include the following two components:
      1) Nonmetallic conducting, material complying with NEMA WC 70/ICEA S-95-658 and UL 1072, extruded over, and free stripping from the insulation.
      2) Metallic Tape Shield: Bare copper, 5-mil (0.127-mm) minimum thickness, helically applied with a 15 percent minimum overlap.
   f. Conductor Jacket: Extruded, chlorosulfonated-polyethylene-based material, complying with NEMA WC 70/ICEA S-95-658.
   g. Messenger: Copper **OR** Composite copper and copper, **as directed**,-clad steel.
   h. Conductor Support Strap: Copper strap, wound around conductors and messenger the full length of the cable.
4. Secondary-Voltage Line Conductors: Aluminum conductor, steel **reinforced**, complying with ASTM B 232/B 232M **OR** Covered aluminum conductor, steel reinforced, complying with ICEA S-70-547, with HDPE or XLP covering, **as directed**, 60 mils (1.52 mm) thick.
   OR
   Secondary-Voltage Line Conductors: Bare hard-drawn copper, complying with ASTM B 1 and ASTM B 8 **OR** Covered hard-drawn copper, complying with ICEA S-70-547, with HDPE or XLP covering, **as directed**, 60 mils (1.52 mm) thick. Neutral-supported, secondary service-drop cable, **as directed**.
   OR
   Racked Secondary Conductors, 600 V and Less: Copper, insulated with XLP, complying with NEMA WC 70/ICEA S-95-658, **as directed**.
5. Neutral-Supported, Secondary Service-Drop Cable, 600 V and Less: Insulated conductors with bare neutral, complying with ICEA S-76-474, and using the following combination of materials:
   a. Conductors and Neutral: Copper with copper-clad-steel neutral **OR** Aluminum with bare Alloy 1350 aluminum neutral **OR** Aluminum with ACSR neutral, **as directed**.
   b. Insulation: XLP, complying with NEMA WC 70/ICEA S-95-658 **OR** High-modular-weight, low-density polyethylene **OR** Weather-resistant polyolefin, complying with ICEA S-70-547, **as directed**.
6. Connectors, Splices, and Conductor Securing and Protecting Components: Items include wire clamps, ties, conductor armor, fittings, connectors, and terminals. Listed for the specific applications and conductor types and combinations of materials used. Descriptions as follows for various applications:
   a. Copper to Copper: Copper alloy, complying with UL 486A-486B.
   b. Aluminum Composition to Aluminum Composition: Aluminum alloy, complying with UL 486A-486B.
   c. Copper to Aluminum Composition: Type suitable for this purpose, complying with UL 486A-486B.
   d. Connectors and Splices for Secondary Conductors: Listed and labeled for the conditions and materials involved in each application.
   e. Taps for Medium-Voltage Line Conductors: Hot-line clamps, screw type, with concealed threads and bare, hard-drawn copper stirrups. Listed for the combination of materials being connected.
   f. Splices under Tension: Compression type with strength exceeding the conductors spliced.

g. Splices and Terminations for Covered Conductors: As recommended by conductor manufacturer for conductor and covering combination and for specific materials and physical arrangement of each splice.
h. Splices and Terminations for Insulated Medium-Voltage Conductors: Comply with requirements in Division 16 Section "Medium-voltage Cables".

B. Wood Poles
1. Comply with ATIS O5.1 and RUS Bulletin 1728F-700, for wood poles pressure treated with creosote **OR** pentachlorophenol, **as directed**, **OR** ammoniacal copper arsenate, **OR** ammoniacal copper zinc arsenate **OR** chromated copper arsenate, **as directed**.
2. Wood Species: Douglas fir **OR** Lodgepole pine **OR** Western larch **OR** Southern yellow pine, **as directed**.
3. Pole Marking:
a. Manufacturer's Mark: Comply with ATIS O5.1; locate 10 feet (3 m) from the pole butt for poles 50 feet (15 m) long or less.
b. Pole Number: Machine-embossed aluminum, alphanumeric characters not less than 2-1/2 inches (65 mm) high, with aluminum nails.
4. Factory Operations: Machine trim poles by turning smooth, full length. Roof, gain, and bore poles before pressure treatment.

C. Concrete Poles
1. Description: Spuncast prestressed concrete, complying with requirements of ASTM C 1089.
a. Comply with requirements of RUS Bulletin 1724E-216.
2. Design: Base design on calculation of strength required by IEEE C2 or indicated on Drawings, whichever is greater. Design shall be suitable for installation at a location where annual temperature range is between minus 4 deg F and plus 100 deg F (minus 20 deg C and plus 38 deg C). Include pole design for embedded attachments matching fittings, brackets, and other items installed in the field.
3. Shaft: Hollow, for poles at overhead-to-underground connections. Provide 3-1/2-inch- (89-mm-) minimum cable raceway capacity, with conduit elbow **OR** cable entry port, **as directed**, at base.
4. Water Absorption: Not more than 3 percent.
5. Surface: Smooth, hard, nonporous, and resistant to soil acids **OR** road salts **OR** frost and freezing damage, **as directed**.
6. Pole Marking:
a. Manufacturer's Mark: Comply with ATIS O5.1; locate 10 feet (3 m) from the pole butt for poles 50 feet (15 m) long or less.
b. Pole Number: Machine-embossed aluminum, alphanumeric characters not less than 2-1/2 inches (65 mm) high.

D. Crossarms
1. Description: Solid-wood distribution type, complying with RUS Bulletin 1728H-701 for specified construction grade **OR** Galvanized, steel angles, **as directed**, and complying with IEEE C2 for required climbing space and wire clearances.
2. Braces: Galvanized, flat, ferrous-metal units; 1/4 inch (6 mm) thick by 1-1/4 inches (30 mm) wide, minimum, with length to suit crossarm dimensions.

E. Guys And Anchors
1. Guy Strand Assemblies: Cable and attachment assemblies shall have uniform minimum breaking strength of the cable.
2. Cable: Seven strands. Zinc-coated steel, complying with ASTM A 475 **OR** Aluminum-clad steel, complying with ASTM B 416 **OR** Copper-clad steel, complying with ASTM B 228, **as directed**. Breaking strength shall be not less than 10,000 lb (45 kN).
3. Cable Termination:
1) Thimble eye.
OR

Hooks and guy strain plates, complying with IEEE C135.1.
2) Preformed galvanized-steel guy grips, matching material, galvanizing, and strength of the guy strand assembly.

4. Anchor and Anchor-Rod Assemblies: Hot-dip galvanized steel.
   a. Power-installed screw-type anchors.
      1) 15-inch (380-mm) screw; with rod 96 inches (2400 mm) long by 1-1/2 inches (38 mm) in diameter. Rated at 10,000 lb (45 kN) when installed.
      2) Guy anchors shall have strength and holding area as required for anchor load and soil conditions at location of that anchor.
5. Strain Insulators: Epoxy-bonded fiberglass of length to meet clearance requirements specified in "Guy Installation" Article.
6. Guy Markers: Round, of vinyl or PVC material, white **OR** yellow, **as directed**, color, 96 inches (2440 mm) long. Shatter resistant at temperatures below 0 deg F (minus 18 deg C).

F. Hardware And Accessories
1. Description: Ferrous-metal items include, but are not limited to, bolts, nuts, washers, crossarm gains and braces, insulator pins, anchor rods, anchors, eyebolts, staples, and transformer brackets.
   a. Comply with IEEE C135.1, IEEE C135.2, ANSI C135.4, ANSI C135.22, and RUS Informational Publication 202-1 listings with the exception that base material shall be malleable iron or ductile iron, and finish shall be hot-dip galvanized, **as directed**.
2. Insulator Brackets: Hot-dip galvanized steel, style as indicated, designed to hold vertical-post-type or pin-type insulators, with one **OR** two, **as directed**,-bolt attachment to pole.
3. Secondary Insulator Racks: Hot-dip galvanized steel, style as indicated, with smooth, rounded 12-gage struts designed to support two **OR** three **OR** four, **as directed**, spool insulators for attachment of secondary drop conductors. Spool spacing of 4 inches (100 mm) **OR** 8 inches (200 mm) **OR** 12 inches (300 mm), **as directed**.
4. Pole Riser Shields: Galvanized steel with boot **OR** backplate **OR** vent, **as directed**.
5. Padlocks: ASTM F 883.
   a. Class: PO1 **OR** PO2, **as directed**.
   b. Grade: 1 **OR** 2 **OR** 3 **OR** 4 **OR** 5 **OR** 6, **as directed**.
   c. Option: A **OR** B **OR** C **OR** D **OR** E **OR** F **OR** G, **as directed**.
6. Insulators: Units rated 6 kV and above shall be free from radio interference.
   a. Porcelain insulators shall be wet-process type, complying with the following:
      1) Pin: ANSI C29.5.
      2) Line Post: ANSI C29.7. Include mounting stud of length suitable for each mounting arrangement used.
      3) Suspension: ANSI C29.2.
      4) Guy Strain: ANSI C29.4.
      5) Secondary Spool: ANSI C29.3, Class 53-2.
   b. Polymer-composite, fiberglass-reinforced insulators shall comply with the following:
      1) Line Post: CEA LWIWG-02.
      2) Dead End/Suspension: CEA LWIWG-01.
      3) Guy Strain: Fiberglass reinforced, epoxy finished. Designed specifically for use in guy assemblies.
7. Grounding Materials: Comply with Division 16 Section "Grounding And Bonding", using materials listed by RUS for the intended purpose without restriction.
   a. Conductors: No. 4 AWG, minimum; bare, solid, annealed copper, complying with ASTM B 8 unless otherwise indicated.
   b. Ground Conductor Protectors: PVC or half-round wood molding, fir, pressure treated according to AWPA C25 **OR** cypress **OR** cedar, **as directed**.

G. Surge Arresters
1. Distribution-Class Surge Arresters: Porcelain **OR** Polymer, **as directed**,-enclosed, gapless, metal-oxide type with automatic-indicating type, ground-lead disconnection feature, **as directed**, complying with IEEE C62.11 and NEMA LA 1.

2. Intermediate-Class Surge Arresters: Porcelain **OR** Polymer, **as directed**,-enclosed, gapless, metal-oxide type, complying with IEEE C62.11 and NEMA LA 1.
   a. Voltage Rating: 3 **OR** 6 **OR** 9 **OR** 10 **OR** 12 **OR** 15 **OR** 27 **OR** 30 **OR** 36, **as directed**, kV, at the altitude of Project, unless otherwise indicated.

H. Cutouts, Switches, And Fuses
1. Description: Medium-voltage disconnect, protective, and bypass, **as directed**, units shall be rated for the line-to-line voltage of the systems in which installed, unless higher ratings are indicated. BIL ratings are 45 **OR** 60 **OR** 75 **OR** 95 **OR** 150 **OR** 200, **as directed**, kV.
   a. Momentary Current Rating of Switching Devices: 20 **OR** 40, **as directed**, kA, asymmetrical at nominal system operating voltage.
   b. Fuse Characteristics: Time-current characteristics for each set of fuses selected according to written recommendations of manufacturer of component protected by the fuses and coordinated with upstream and downstream protective devices. Prepare time-current coordination curves according to IEEE 242 that illustrate optimum coordination of devices in this Project.
   c. Interrupting Rating of Fuses: <**Insert value**> symmetrical A at nominal system operating voltage.
2. Fuse Cutouts: Open **OR** enclosed, **as directed**, type, rated 100 **OR** 200, **as directed**, A, continuous, complying with ANSI C37.42.
   a. Fuses: Enclosed link, Type K **OR** Type T, **as directed**, complying with ANSI C37.42.
   b. Fuse Current Rating: 150 percent of the transformer full-load current unless otherwise indicated.
   c. Switching Application: Include switch link instead of fuse.
   d. Switch Current Interrupting Rating: Transformer magnetizing current.
3. Fused Switches: Single-pole, manual units.
   a. Switch Rating: 400 **OR** 600, **as directed**,-A rms continuous and load-current interrupting.
   b. Fuses: Dropout-type power fuses.
4. Nonfused Switches: Single-pole, manual units, rated 100 **OR** 200 **OR** 400 **OR** 600, **as directed**,-A rms continuous.
5. Group-Operated, Load-Interrupter Switches: Fused **OR** Nonfused, **as directed**, three-pole, single-throw units, manually operated by handle through insulated mechanical linkage.
   a. High-pressure contact type, complying with ANSI C37.32.
   b. Factory assembled to suit specific configuration and mounting conditions for this Project.
   c. Operating Handle: Padlock equipped.
   d. Current Interrupting Rating: Equal to continuous current rating of switch.
   e. Fuses: Nondropout power type.
6. Group-Operated, Air-Break (Nonloadbreak) Switches: Three-pole, single-throw units, manually operated by handle through insulated mechanical linkage.
   a. Comply with ANSI C37.32.
   b. Factory assembled to suit specific configuration and mounting conditions for this Project.
   c. Operating Handle: Padlock equipped.
   d. Suitable for field conversion to load-interrupter switch by adding interrupter modules.

I. Distribution Transformers
1. Description: Single-phase, two-winding, single **OR** two, **as directed**,-bushing, liquid-filled, self-cooled, pole-mounting distribution type, suitable for external fuse and surge suppressor protection; complying with IEEE C 57.12.00, and tested according to IEEE C 57.12.90 and with the following additional requirements, **as directed**:
   a. Cooling Class: OA.
   b. Temperature Rise: 65 deg C.
   c. Insulating Liquid: Mineral oil, ASTM D 3487, Type II.
      OR
      Insulating Liquid: High molecular weight, mineral oil based, and UL listed as less-flammable type.

OR
Insulating Liquid: Biodegradable insulating and cooling liquid, UL listed as less flammable type.

d. Identification: Label the transformer as "non-PCB" and place manufacturer's name and type of fluid on the nameplate.

2. BIL: 95 **OR** 75 **OR** 60, **as directed**, kV.
3. Taps: Two, 2.5 percent above and below **OR** Four, 2.5 percent below, **as directed**, high-voltage and full-load rated. Tap changer shall have an external operating handle, **as directed**.
4. Mounting Brackets: Single **OR** Double, **as directed**, integral; suitable for pole mounting, individually or in cluster, or on crossarm.
5. Minimum Efficiency: Class 1, as defined by NEMA TP 1, based on test results that comply with requirements of NEMA TP 2.
6. Bushings: Creepage distance shall exceed nominal value standard for unit rating by at least 75 percent.
7. Hardware: Stainless steel.
8. Tank and Cover: Stainless steel, complying with ASTM A 167, Type 304 or 304L, with paint coating exterior finish system complying with IEEE C57.12.28, including manufacturer's standard color finish coat.
9. Show transformer kiloampere capacity using 2-1/2-inch (65-mm) numerals placed near the low-voltage bushings.

J. Primary Metering Equipment

1. Metering Transformers: Outdoor current and potential transformers, designed for crossarm mounting, complying with IEEE C57.13, and having the following features:
   a. BIL: 45 **OR** 60 **OR** 75 **OR** 95 **OR** 150 **OR** 200, **as directed**, kV.
   b. Secondary connection box arranged for conduit connection.
   c. Potential-Transformer Voltage Rating: 2.4 **OR** 4.16 **OR** 7.2 **OR** 12.0 **OR** 12.47, **as directed**, kV to 120-V ac, 60 Hz.
   d. Potential-Transformer Accuracy Class: Minimum 0.3 at 75-VA burden.
   e. Voltage Rating: 2.4 **OR** 4.16 **OR** 7.2 **OR** 12.0 **OR** 12.47, **as directed**, kV.
   f. Current Rating: <**Insert value**> to 5 A.
   g. Accuracy Class: Minimum 0.2 at 50-VA burden.
2. Watt-Hour Meter: Outdoor solid-state unit, with demand register, **OR** arranged for pulse initiation, **as directed**, complying with ANSI C12.10, and including the following ratings and features:
   a. Form: 8S **OR** 9S, **as directed**.
   b. Element: 2 **OR** 2-1/2 **OR** 3, **as directed**.
   c. Voltage: 120 V.
   d. Current: 2-1/2 A.
   e. Frequency: 60 Hz.
   f. Kilowatt-Hour Register: Five-digit type.
   g. Demand-Register Multiplier: A quantity in even hundreds, indicated on meter face.
   h. Demand-Register Interval: 15 **OR** 30, **as directed**, minutes.
   i. Mounting: On matching socket, complying with ANSI C12.7, and complete with automatic current short-circuiting device.
   j. Meter Test Block: Matched to meter, and furnished and equipped with open knife switches designed to isolate each metering component for test.
   k. Meter Cabinet: Galvanized steel; weatherproof enclosure with pole-mounting bracket and the following features:
      1) Hinged Door: Arranged for padlocking in closed position.
      2) Size: Adequate to house meter and other equipment indicated, but not less than 20 by 30 by 11 inches (510 by 760 by 280 mm) deep.

K. Source Quality Control

1. Factory Tests: Conduct routine tests of transformers **OR** medium-voltage switches **OR** metering equipment, **as directed**, according to referenced standards.

2. Testing Agency: Engage a qualified testing agency to inspect poles and crossarms before and after preservative treatment for compliance of wood poles and crossarms with requirements indicated. RUS quality mark "WQC" on each item is acceptable in place of inspection as evidence of compliance.
3. Poles and crossarms will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

1.3 EXECUTION

A. Right-Of-Way Clearance And Tree Trimming
1. Clear right of way according to Division 02 Section(s) "Tree Protection And Trimming" AND "Site Clearing".
2. Clear right of way to maintain minimum clearances required by IEEE C2, unless Drawings indicate greater clearances or greater clearances are required by state or local codes or regulations. If no minimum requirements are mandated, maintain a minimum of 15 feet (4.5 m) on both sides horizontally and below medium-voltage conductors and 60 inches (1500 mm) on both sides horizontally and below secondary-voltage conductors. Remove overhanging branches.

B. General Installation Requirements
1. Install underground power and metering circuits and those circuits indicated to be in raceways according to Division 02 Section "Underground Ducts And Utility Structures" and Division 16 Section "Medium-voltage Cables", and make splices and terminations for those circuits according to the applicable Sections.
2. Engage the services of a licensed surveyor to verify dimensions by field measurement, to identify locations of poles, anchors, and other features, and to verify all clearances. The survey document shall also identify locations of connections to new and existing supply lines and to primary and secondary services. Notify the Owner of discrepancies and field conditions that are not indicated and that will affect installation.
3. Ground equipment according to Division 16 Section "Grounding And Bonding".
4. Apply warning signs and equipment labels according to Division 16 Section "Electrical Identification".

C. Conductor Installation, General
1. Handle and string conductors to prevent cuts, gouges, scratches, kinks, flattening, or deformation. Remove damaged sections and splice conductors.
   a. String new conductors to "initial" sag values recommended by manufacturer for type and size of conductor except as otherwise indicated.
   b. Conductors Reinstalled or Resagged: String to "final" sag values recommended by manufacturer for type and size of conductor except as otherwise indicated.
2. Connections, Splices, and Terminations: Use kits listed for the specific type of connection and combination of materials in the connection or recommended for the specific use by manufacturer of material on which applied.
   a. Splice Location: Do not install within 10 feet (3 m) of a support.
   b. Line Conductors and Service Drops: Install so strength exceeds ultimate rated strength of conductor.
   c. Splices and Terminations of Covered Conductors: Comply with manufacturer's written instructions.
   d. Splices and Terminations of Insulated Conductors of Self-Supported, Medium-Voltage Cable: Comply with manufacturer's written instructions.

D. Medium-Voltage Line Conductor Installation
1. Application: Install bare conductors unless otherwise indicated.
2. Armor Rod: Install to protect conductors if line conductors are supported by insulators.

3. Flat Aluminum Armor Wire: Install to protect conductors if they are supported by, or attached to, galvanized or coated iron or steel clamps or fittings.
4. Support line conductors and taps as follows:
   a. Use wire ties for conductor attachment to pin and vertical post insulators unless otherwise indicated.
   b. Install wire ties tight against conductor and insulator, and turn ends back and flat against conductor, to eliminate exposed wire ends.
   c. Use wire clamps on horizontal post, dead end, and suspension insulators unless otherwise indicated.

E. Pole And Crossarm Installation
1. Pole Orientation: Align curve of curved wood poles with straight-line runs of three or more poles. Align gained surfaces perpendicular to runs.
2. Elevation of Line above Grade: Install poles with top at same elevation, unless grade changes dictate elevation change in poles, and according to the following:
   a. On level ground, set poles so tops of consecutive poles vary not more than 60 inches (1500 mm) in elevation.
   b. Shorten wood poles by cutting off the top and make cuts to shed water. Apply preservative to cuts.
3. Set poles according to the following:
   a. Make pole holes vertical, uniform in diameter, and large enough to permit effective use of tamping bars all around. Bore or excavate holes with an average diameter at grade less than twice the diameter of the pole at the same grade.
   b. Use minimum depths indicated, except at locations where hole is partly or entirely in rock and if hole is not vertical or has a diameter at grade more than two times the pole diameter at the same level; in these conditions, increase the depth of the hole by the following increments before setting the pole:
      1) Poles up to 35 Feet (10.6 m) Long: 24 inches (600 mm).
      2) Poles 36 to 60 Feet (11 to 18.3 m) Long: 30 inches (760 mm).
      3) Poles 61 to 75 Feet (18.6 to 22.9 m) Long: 36 inches (900 mm).
   c. For poles on slopes, indicated hole depth is from finished grade at lowest side of hole.
   d. Set poles in alignment and plumb except at dead ends, angles, and points of extra strain; rake poles against conductor strain 1 inch (25 mm) minimum, 2 inches (51 mm) maximum, (after conductors are installed at required tension) for each 10 feet (3 m) of pole length. Rake poles so they will not lean or bend in direction of strain when loaded.
   e. Backfill holes in 6-inch (150-mm) maximum lifts, and thoroughly tamp each layer before starting the next.
   f. Place surplus earth around pole in a conical shape, and tamp thoroughly to provide drainage away from pole.
   g. Set poles so alternate crossarm gains face in alternate directions, except at terminals and dead ends; place gains on last two poles on side facing terminal or dead end.
   h. Poles Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
4. Field treat factory-treated poles and crossarms as follows:
   a. Poles Treated More Than One Year before Installation: Treat portion from 24 inches (600 mm) above ground line to butt.
   b. Field-Bored Holes and Field-Cut Gains and Pole Tops: Treat cut portions.
   c. Unused Holes: Treat and plug with treated-wood-dowel drive pins.
   d. Engage the services of a technician certified according to "Quality Assurance" Article to apply treatment. Comply with requirements in AWPA standards that govern original factory treatment for field-applied treatment and application of chemicals.
5. Crossarm Installation: Set line crossarms at right angle to line for straight runs and for angles 45 degrees and more. Bisect angles less than 45 degrees.
   a. Buck Arms: Install at corners and junction poles unless otherwise indicated.
   b. Double Crossarms: Install at dead ends, corners, angles, and line crossings.

c. Equipment Arms: Locate below lines and set parallel or at right angles to them, whichever provides best climbing space.
d. Gains: Install factory-cut or metal-pole gains only. Do not cut gains in field without specific written approval.

6. Locate pole numbers to provide maximum visibility from the road or patrol route.

F. Guy Installation

1. Install guys to resist unbalanced loads, including those developed at angles, corners, and dead ends. Install two or more guys if a single guy will not provide adequate strength. Install separate guys if unbalanced loads are separated by 36 inches (900 mm) or more. Comply with IEEE C2.
   a. Unless a thimble eye is used, at the pole end, install a minimum of two guy hooks and two guy strain plates.
   b. At the anchor end, attach guy strand assembly with preformed grips.
2. Protect guy strands from damage. Replace damaged guy strands. Install guy insulators where required to comply with IEEE C2 clearance requirements.
3. Install guys with a lead-to-height ratio of 1 to 1 unless otherwise indicated. The minimum lead-to-height ratio shall be 1/2 to 1. When less than 1 to 1, increase guy strength by the ratio of the sine of the lead angle indicated to the sine of the lead angle provided.
4. Install screw-type guy anchors aligned in soil with guy. Set with anchor rod pointing at guy attachment on pole and rod projecting 6 to 9 inches (150 to 230 mm) from ground.
5. Install strain insulators to provide a minimum of 12 inches (300 mm) of clearance between the nearest energized surface and the strain insulator fitting farthest from the pole. When loaded to the tension indicated, fiberglass strain insulators shall be loaded to not more than two-thirds of manufacturer's published rating.
6. Guy Markers: Install at anchor end of guys to visually mark the guy wire at all accessible locations. Clamp to guy strand or anchor at top and bottom of marker.

G. Hardware And Accessories Installation

1. Install washers against wood and under nuts, including eyenuts and locknuts.
2. Install nuts and locknuts wrench-tight on threaded connections.

H. Insulator Installation

1. Medium-Voltage Line Application: Install pin **OR** post, **as directed**, type, except install suspension type at corners, angles, dead ends, and other locations where horizontal forces exceed rated values for pin or line-post-type units.
   a. Install suspension insulators and hardware that have mechanical strength exceeding rated breaking strength of attached conductors.
   b. Install horizontal line-post insulators for armless construction.
2. Post-Insulator Conductor Support: Where installed horizontally and for line angles more than 15 degrees, install clamp-top conductor clamps.
3. Install spool-type insulators for secondary lines mounted on clevis attachments or secondary racks.
4. Guy Strain Type: Install porcelain **OR** fiberglass-reinforced, **as directed**, units.

I. Surge Arresters

1. Install surge arresters to protect distribution **OR** metering equipment **OR** reclosers, **as directed**, group-operated, load-interrupter switches, **as directed**, aerial-to-underground transitions, **as directed**, and other items indicated.
   a. Units Installed 6000 Feet (1800 m) or More above Sea Level: Use arresters specifically rated for this service.

J. Cutout, Switch, And Fuse Installation

1. Hook-Stick-Operated Switches: Install to maximize safe operating access.
2. Group-Operated, Load-Interrupter Switches and Air-Break Switches: Install operating handle 42 inches (1067 mm) above finished grade.

a. Locking Provisions: Install padlock at hasp.

K. Metering Component Installation
1. Current and Voltage Transformers: Install secondary conductors between transformers and cabinet in sleeves made of galvanized rigid steel **OR** intermediate metal **OR** PVC, **as directed**, conduit. Install to prevent collection of moisture in raceway and cabinet system.
2. Meter Cabinet: Mount on pole, 72 inches (1825 mm) above finished grade to center of cabinet.
   a. Make conduit connections with raintight hubs.
   b. Install metering transformer secondary leads without splices. Train leads at sides and bottom of enclosure, and secure with wire ties.
   c. Install meter and meter test block within cabinet.
   d. Install identical phase sequence, and color-code for both potential and current leads.
   e. Identify leads using designations consistent with marking on transformer terminals.

L. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Tests and Inspections:
   a. Furnish instruments and equipment required for tests that comply with NETA Acceptance Testing Specification.
   b. Guy Anchors: Test one of each type and capacity installed, plus additional units specifically indicated for testing, **as directed**. Apply rated pull-out force in the same pull direction applied by the guy at the test location.
      1) Acceptable Test Results: Denoted by movement of less than 3/8 inch (10 mm) by the holding component of the anchor in the earth or other medium in which it is installed.
      2) Replace or reinstall, at the Owner 's option, all anchors of same type and capacity as anchor type that fails this test.
   c. Ground Resistance: Comply with Division 16 Section "Grounding And Bonding". Measure resistance of each separate grounding electrode, including pole grounds. Also measure resistance of separate grounding electrode systems before bonding together.
      1) Perform tests and obtain acceptable results before energizing any portion of overhead electrical distribution system.
      2) Results and Follow-up: If ground resistance for a single ground electrode or pole ground, tested individually, exceeds 25 ohms, add a ground electrode not less than 10 feet (3 m) away and interconnect with No. 2 AWG, minimum, bare conductor buried at least 12 inches (300 mm) below furnished grade.
   d. Aerial Conductor Sag and Tension: Observe procedures used by Contractor to verify that initial stringing sags and tensions comply with IEEE C2 and conductor manufacturer's product data and written recommendations.
   e. Self-Supported, Medium-Voltage Cable: After installation, while cable is isolated, and after terminations are installed and before connecting or energizing, apply dc voltage between each phase conductor and grounding connections of sheath or metallic shield. Comply with NEMA WC 70/ICEA S-95-658 for method, voltage, duration, pass-fail performance, and other test criteria. Perform other field inspections and tests recommended by manufacturer.
   f. Neutral-Supported, Secondary Service-Drop Cable: Test for insulation resistance while cable is isolated, before connecting or energizing. Minimum acceptable resistance is 100 megohms.
   g. Existing Surge Arresters: Disconnect and measure resistance between line and ground terminals with a megger test rated 600 V or more. Acceptable resistance values are 300 megohms and more.
   h. New Surge Arresters, Cutouts, and Switches: Inspect after installation and connection to wiring. Verify that ratings and characteristics match approved submittals and comply with system requirements. Verify that installation complies with requirements and that clearances of units and connecting wiring comply with IEEE C2 requirements.

1) Verify proper grounding of metallic equipment parts.
2) Fuses and Disconnect Links: Verify that ratings and characteristics match submittals and comply with system requirements.
3) Switches:
   a) Manually operate each cutout and switch at least three times, to verify proper operation.
   b) Verify correct contact alignment, blade penetration, travel stops, and arc interrupter operation.
4) Group-Operated, Load-Interrupter Switches and Air-Break Switches:
   a) Perform mechanical operator tests according to manufacturer's written instructions.
   b) Test resistance to ground of parts to be energized. Acceptable value is 200,000 megohms.
   c) Perform contact-resistance test across all switch blade contacts. Refer to manufacturer's data for acceptable contact resistance.
5) Verify that clearances of energized parts and connecting wires comply with IEEE C2 requirements.

i. Distribution Transformers: Inspect after installation and connection to wiring and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.
   1) Inspect for physical damage, cracked insulators, leaks, tightness of connections, and overall mechanical and electrical integrity.
   2) Perform preenergizing inspections and tests recommended by manufacturer.
   3) Verify proper equipment grounding.
   4) Verify that clearances of terminals and connecting wires comply with IEEE C2.

j. Metering Transformers: Inspect after installation and connection to wires, and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.
   1) Verify proper connections, tightness of bolted connections, and integrity of mounting provisions.
   2) Verify that required grounding and shorting connections provide good contact.
   3) Verify that clearances of terminals and connecting wires comply with IEEE C2.
   4) Perform electrical tests according to manufacturer's written instructions, including insulation-resistance tests, polarity tests, and turns-ratio and ratio-verification tests.

k. Meters: Inspect after installation and connection to wiring and verify that ratings and characteristics match approved submittals and comply with system requirements. Verify the integrity and good condition of unit.
   1) Verify tightness of electrical connections.
   2) Verify accuracy at 25, 50, 75, and 100 percent of full-rated load and verify all instrument multipliers according to manufacturer's written instructions.

4. Prepare test and inspection reports.

M. Adjusting
1. Distribution Transformers: Set voltage taps as directed by the Owner.

N. Cleaning
1. After completing equipment installation, inspect equipment. Remove spots, dirt, and debris. Repair damaged finish to match original finish. For distribution transformer, use tank touchup paint provided by manufacturer.
   a. Clean enclosures internally, on completion of installation, according to manufacturer's written instructions.

O. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain overhead electrical distribution.

END OF SECTION 16330a

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SECTION 16330b - LOW-VOLTAGE TRANSFORMERS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for low-voltage transformers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
   a. Distribution transformers.
   b. Buck-boost transformers.

C. Submittals
1. Product Data: For each product indicated.
2. Shop Drawings: Indicate dimensions and weights.
   a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Field quality-control test reports.
5. Operation and maintenance data.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

E. Delivery, Storage, And Handling
1. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.2 PRODUCTS

A. General Transformer Requirements
1. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
2. Cores: Grain-oriented, non-aging silicon steel.
3. Coils: Continuous windings without splices except for taps.
   a. Internal Coil Connections: Brazed or pressure type.
   b. Coil Material: Aluminum **OR** Copper, **as directed**.

B. Distribution Transformers
1. Comply with NEMA ST 20, and list and label as complying with UL 1561.
2. Provide transformers that are constructed to withstand seismic forces specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
3. Cores: One leg per phase.
4. Enclosure: Ventilated **OR** Totally enclosed, nonventilated, **as directed**, NEMA 250, Type 2.

a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

5. Enclosure: Ventilated **OR** Totally enclosed, nonventilated, **as directed**, NEMA 250, Type 3R **OR** Type 4X, stainless steel, **as directed**.
   a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
6. Transformer Enclosure Finish: Comply with NEMA 250.
   a. Finish Color: Gray **OR** ANSI 49 gray **OR** ANSI 61 gray, **as directed**.
7. Taps for Transformers Smaller Than 3 kVA: None **OR** One 5 percent tap above normal full capacity, **as directed**.
8. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity **OR** Two 5 percent taps below rated voltage, **as directed**.
9. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity **OR** Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity, **as directed**.
10. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 **OR** 115 **OR** 80, **as directed**, deg C rise above 40 deg C ambient temperature.
11. Energy Efficiency for Transformers Rated 15 kVA and Larger:
    a. Complying with NEMA TP 1, Class 1 efficiency levels.
    b. Tested according to NEMA TP 2.
12. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
    a. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
    b. Indicate value of K-factor on transformer nameplate.
13. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
14. Wall Brackets: Manufacturer's standard brackets.
15. Fungus Proofing: Permanent fungicidal treatment for coil and core.
16. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

C. Buck-Boost Transformers
1. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.
2. Enclosure: Ventilated, NEMA 250, Type 2.
   a. Finish Color: Gray **OR** ANSI 49 gray **OR** ANSI 61 gray, **as directed**.

D. Identification Devices
1. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 16 Section "Electrical Identification".

1.3 EXECUTION

A. Installation
1. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
   a. Brace wall-mounting transformers as specified in Division 16 Section "Hangers And Supports For Electrical Systems".
2. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, **as directed**, and requirements in Division 16 Section "Hangers And Supports For Electrical Systems".

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
   a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   b. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
      1) Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
      2) Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
      3) Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

C. Adjusting
1. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
2. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
3. Output Settings Report: Prepare a written report recording output voltages and tap settings.

D. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16330b

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Task	Specification	Specification Description
16350	16320	Switchgear
16430	16330a	Overhead Electrical Distribution

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SECTION 16450 - LIGHTNING PROTECTION

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for lightning protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes lightning protection for structures, structure elements and building site components.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For air terminals and mounting accessories.
   a. Layout of the lightning protection system, along with details of the components to be used in the installation.
   b. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
3. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.
4. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.
5. Field quality-control reports.
6. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.
7. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
   a. Ground rods.
   b. Ground loop conductor.

D. Quality Assurance
1. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.
2. System Certificate:
   a. UL Master Label.
      OR
      LPI System Certificate.
      OR
      UL Master Label Recertification.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

E. Coordination
1. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
2. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
3. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

1.2 PRODUCTS

A. Lightning Protection System Components
1. Comply with UL 96 and NFPA 780, **as directed**.
2. Roof-Mounted Air Terminals: NFPA 780, Class I **OR** Class II, **as directed**, aluminum **OR** copper, **as directed**, unless otherwise indicated.
   a. Air Terminals More than 24 Inches (600 mm) Long: With brace attached to the terminal at not less than half the height of the terminal.
   b. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 05.
3. Main and Bonding Conductors: Copper **OR** Aluminum, **as directed**.
4. Ground Loop Conductor: The same size and type as the main conductor except tinned.
5. Ground Rods: Copper-clad **OR** Zinc-coated **OR** Stainless, **as directed**, steel, sectional type, **as directed**; 3/4 inch (19 mm) in diameter by 10 feet (3 m) **OR** 5/8 inch (16 mm) in diameter by 96 inches (2400 mm), **as directed**, long.
6. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Stainless steel **OR** Solid copper **OR** Monel metal **OR** Lead sheathed, **as directed**.

1.3 EXECUTION

A. Installation
1. Install lightning protection components and systems according to UL 96A and NFPA 780.
2. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
3. Conceal the following conductors:
   a. System conductors.
   b. Down conductors.
   c. Interior conductors.
   d. Conductors within normal view of exterior locations at grade within 200 feet (60 m) of building.
4. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.
   OR
   Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
   a. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
5. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.
6. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.
7. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure **OR** area or item indicated, **as directed**.
   a. Bury ground ring not less than 24 inches (600 mm) from building foundation.
   b. Bond ground terminals to the ground loop.
   c. Bond grounded building systems to the ground loop conductor within 12 feet (3.6 m) of grade level.
8. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot (18-m) intervals.

B. Corrosion Protection
1. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

2. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.

C. Field Quality Control
1. Notify the Owner at least 48 hours in advance of inspection before concealing lightning protection components.
2. UL Inspection: Meet requirements to obtain a UL Master Label for system.
OR
LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

END OF SECTION 16450

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SECTION 16451 - GROUNDING AND BONDING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for grounding and bonding. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes methods and materials for grounding systems and equipment, plus the following special applications, **as directed**:
   a. Overhead-lines grounding.
   b. Underground distribution grounding.
   c. Common ground bonding with lightning protection system.

C. Submittals
1. Product Data: For each type of product indicated.
2. Field quality-control test reports.

D. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with UL 467 for grounding and bonding materials and equipment.

1.2 PRODUCTS

A. Conductors
1. Insulated Conductors: Copper **OR** Tinned-copper, **as directed**, wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
2. Bare Copper Conductors:
   a. Solid Conductors: ASTM B 3.
   b. Stranded Conductors: ASTM B 8.
   c. Tinned Conductors: ASTM B 33.
   d. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
   e. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
   f. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
   g. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
3. Bare Grounding Conductor and Conductor Protector for Wood Poles:
   a. No. 4 AWG minimum, soft-drawn copper.
   b. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
4. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm), **as directed**, in cross section, unless otherwise indicated; with insulators.

B. Connectors

1. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   a. Pipe Connectors: Clamp type, sized for pipe.
3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Grounding Electrodes
1. Ground Rods: Copper-clad **OR** Zinc-coated **OR** Stainless, **as directed,** steel, sectional type, **as directed**; 3/4 inch by10 feet (19 mm by 3 m) **OR** 5/8 by 96 inches (16 by 2400 mm), **as directed,** in diameter.
2. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
   a. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
   b. Backfill Material: Electrode manufacturer's recommended material.

1.3 EXECUTION

A. Applications
1. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
2. Underground Grounding Conductors: Install bare copper **OR** tinned-copper, **as directed**, conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.
   a. Bury at least 24 inches (600 mm) below grade.
   b. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
3. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
4. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   a. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
   b. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
5. Conductor Terminations and Connections:
   a. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   b. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
   c. Connections to Ground Rods at Test Wells: Bolted connectors.
   d. Connections to Structural Steel: Welded connectors.

B. Grounding Overhead Lines
1. Comply with IEEE C2 grounding requirements.
2. Install 2 parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.
3. Drive ground rods until tops are 12 inches (300 mm) below finished grade in undisturbed earth.
4. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.
5. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.

6. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.
7. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.

C. Grounding Underground Distribution System Components
1. Comply with IEEE C2 grounding requirements.
2. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
3. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
4. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

D. Equipment Grounding
1. Install insulated equipment grounding conductors with all feeders and branch circuits.
2. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
   a. Feeders and branch circuits.
   b. Lighting circuits.
   c. Receptacle circuits.
   d. Single-phase motor and appliance branch circuits.
   e. Three-phase motor and appliance branch circuits.
   f. Flexible raceway runs.
   g. Armored and metal-clad cable runs.
   h. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
   i. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
   j. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
3. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
4. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
5. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.

6. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
7. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
   a. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
   b. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
8. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

E. Installation
1. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
2. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
3. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
   a. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
   b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
4. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 02 Section "Underground Ducts And Utility Structures" and shall be at least 12 inches (300 mm) deep, with cover.
   a. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
5. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
   a. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
   b. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
   c. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
6. Grounding and Bonding for Piping:
   a. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

b. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

c. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

7. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.

8. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

9. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column **OR** indicated item, **as directed**, extending around the perimeter of building **OR** area or item indicated, **as directed**.

a. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.

b. Bury ground ring not less than 24 inches (600 mm) from building foundation.

10. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

a. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

b. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

F. Field Quality Control

1. Perform the following tests and inspections and prepare test reports:

a. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.

1) Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.

2) Perform tests by fall-of-potential method according to IEEE 81.

c. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

2. Report measured ground resistances that exceed the following values:

a. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.

b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.

c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 **OR** 3, **as directed,** ohm(s).

e. Substations and Pad-Mounted Equipment: 5 ohms.

f. Manhole Grounds: 10 ohms.

3. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the Owner promptly and include recommendations to reduce ground resistance.

END OF SECTION 16451

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Task	Specification	Specification Description
16451	16330a	Overhead Electrical Distribution
16452	01352	No Specification Required
16452	16450	Lightning Protection
16452	16451	Grounding And Bonding
16453	16450	Lightning Protection
16453	16451	Grounding And Bonding
16453	16330a	Overhead Electrical Distribution
16456	16450	Lightning Protection
16456	16451	Grounding And Bonding
16456	16330a	Overhead Electrical Distribution

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SECTION 16470 - SWITCHBOARDS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for switchboards. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Service and distribution switchboards rated 600 V and less.
b. Transient voltage suppression devices.
c. Disconnecting and overcurrent protective devices.
d. Instrumentation.
e. Control power.
f. Accessory components and features.
g. Identification.
h. Mimic bus.

C. Performance Requirements
1. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For each switchboard and related equipment.
a. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
b. Detail enclosure types for types other than NEMA 250, Type 1.
c. Detail bus configuration, current, and voltage ratings.
d. Detail short-circuit current rating of switchboards and overcurrent protective devices.
e. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
f. Detail utility company's metering provisions with indication of approval by utility company.
g. Include evidence of NRTL listing for series rating of installed devices.
h. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
i. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
j. Include diagram and details of proposed mimic bus.
k. Include schematic and wiring diagrams for power, signal, and control wiring.
3. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
4. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
5. Field Quality-Control Reports.

6. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA PB 2.
3. Comply with NFPA 70.
4. Comply with UL 891.

F. Delivery, Storage, And Handling
1. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
2. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) **OR** connect factory-installed space heaters to temporary electrical service, **as directed**, to prevent condensation.
3. Handle and prepare switchboards for installation according to NECA 400 **OR** NEMA PB 2.1, **as directed**.

G. Project Conditions
1. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   a. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
   b. Indicate method of providing temporary electric service.
   c. Do not proceed with interruption of electric service without Owner's written permission.
   d. Comply with NFPA 70E.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Units
1. Front-Connected, Front-Accessible Switchboards:
   a. Main Devices: Panel **OR** Fixed, individually, **as directed**, mounted.
   b. Branch Devices: Panel mounted.
   c. Sections front and rear aligned.
2. Front- and Side-Accessible Switchboards:
   a. Main Devices: Fixed, individually mounted.
   b. Branch Devices: Panel mounted.
   c. Sections front and rear aligned.
3. Front- and Rear-Accessible Switchboards:
   a. Main Devices: Fixed, individually **OR** Drawout, **as directed**, mounted.
   b. Branch Devices: Panel **OR** Fixed, individually **OR** Panel and fixed, individually **OR** Fixed and individually compartmented **OR** Individually compartmented and drawout, **as directed**, mounted.
   c. Sections front and rear **OR** rear, **as directed**, aligned.
4. Nominal System Voltage: 480Y/277 V **OR** 208Y/120 V, **as directed**.
5. Main-Bus Continuous: 5000 **OR** 4000 **OR** 3000 **OR** 2500 **OR** 2000 **OR** 1600 **OR** 1200, **as directed**, A.

6. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
7. Indoor Enclosures: Steel, NEMA 250, Type 1 **OR** Type 5, **as directed**.
8. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray **OR** custom color, **as directed**, finish over a rust-inhibiting primer on treated metal surface.
9. Outdoor Enclosures: Type 3R **OR** Type 3R, with interior-lighted walk-in aisle, **as directed**.
   a. Finish: Factory-applied finish in manufacturer's standard **OR** custom, **as directed**, color; undersurfaces treated with corrosion-resistant undercoating.
   b. Enclosure: Flat **OR** Downward, rearward sloping, **as directed**, roof; bolt-on rear covers **OR** rear hinged doors, **as directed**, for each section, with provisions for padlocking.
   c. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking **OR** cylinder lock, **as directed**.
   d. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
   e. Walk-in Aisle Heating and Ventilating:
      1) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 104 deg F (40 deg C).
      2) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 23 deg F (minus 5 deg C).
      3) Ventilating openings complete with replaceable fiberglass air filters.
      4) Thermostat: Single stage; wired to control heat and exhaust fan.
   f. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer within the switchboard. Supply voltage shall be 120 **OR** 120/240 **OR** 120/208, **as directed**,-V ac.
   g. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
10. Barriers: Between adjacent switchboard sections.
11. Insulation and isolation for main bus of main section, **as directed**, and main and vertical buses of feeder sections.
12. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
    a. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point **OR** Manual switching of branch-circuit protective device, **as directed**.
    b. Space-Heater Power Source: Transformer, factory installed in switchboard **OR** 120-V external branch circuit, **as directed**.
13. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.
14. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks, **as directed**.
15. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
16. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws **OR** standard bolts, **as directed**, for access to rear interior of switchboard.
17. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

18. Pull Box on Top of Switchboard:
    a. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
    b. Set back from front to clear circuit-breaker removal mechanism.
    c. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
    d. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
    e. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
19. Buses and Connections: Three phase, four wire unless otherwise indicated.
    a. Phase- and Neutral-Bus Material: One of the following:
        1) Hard-drawn copper of 98 percent conductivity, silver-plated, **as directed**, with tin-plated aluminum or copper feeder circuit-breaker line connections.
        2) Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
        3) Hard-drawn copper of 98 percent conductivity, silver-plated, **as directed**, or tin-plated, high-strength, electrical-grade aluminum alloy.
    b. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
    c. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) **OR** 1/4-by-1-inch- (6-by-25-mm-) **OR** Minimum-size required by UL 891, **as directed**, hard-drawn copper of 98 percent conductivity, equipped with mechanical **OR** compression, **as directed**, connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
    d. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
    e. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
    f. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
    g. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
20. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
21. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
22. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

B. Transient Voltage Suppression Devices
1. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in **OR** plug-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
    a. Fuses, rated at 200-kA interrupting capacity.
    b. Fabrication using bolted compression lugs for internal wiring.
    c. Integral disconnect switch.
    d. Redundant suppression circuits.
    e. Redundant replaceable modules.
    f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

g. LED indicator lights for power and protection status.
h. Audible alarm, with silencing switch, to indicate when protection has failed.
i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
j. Four **OR** Six, **as directed**,-digit, transient-event counter set to totalize transient surges.

2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**,-V, three-phase, four-wire circuits shall be as follows:
   a. Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
   b. Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
   c. Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
5. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
   a. Line to Neutral: 400 V, 800 V from high leg.
   b. Line to Ground: 400 V.
   c. Neutral to Ground: 400 V.
6. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
   a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
   b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

C. Disconnecting And Overcurrent Protective Devices
1. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
   a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long- and short-time time adjustments.
      4) Ground-fault pickup level, time delay, and I^2t response.
   d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
   f. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
   g. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
   h. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      1) Standard frame sizes, trip ratings, and number of poles.
      2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.

3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring And Control".
7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2. Insulated-Case Circuit Breaker (ICCB): 80 **OR** 100, **as directed**, percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
   a. Fixed **OR** Drawout, **as directed**, circuit-breaker mounting.
   b. Two-step, stored-energy closing.
   c. Standard **OR** Full, **as directed**,-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
      1) Instantaneous trip.
      2) Long- and short-time time adjustments.
      3) Ground-fault pickup level, time delay, and I^2t response.
   d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   e. Remote trip indication and control.
   f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring And Control".
   g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   h. Control Voltage: 40-V dc **OR** 125-V dc **OR** 250-V dc **OR** 120-V ac, **as directed**.
3. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
   a. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
   b. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
      1) Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
      2) Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
   c. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
   d. Service-Rated Switches: Labeled for use as service equipment.

e. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
   1) Configuration: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   2) Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
   3) No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
   4) Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
f. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

4. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.
   a. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
   b. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
      1) Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
      2) Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
   c. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
   d. Service-Rated Switches: Labeled for use as service equipment.
   e. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
      1) Configuration: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      2) Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
      3) No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
      4) Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
   f. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
5. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
6. Fuses are specified in Division 16 Section "Fuses".

D. Instrumentation
   1. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
      a. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single **OR** tapped **OR** double, **as directed**, secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
      b. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound **OR** bushing **OR** bar or window, **as directed**, type; single **OR** double, **as directed**, secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
      c. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
      d. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   a. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
      1) Phase Currents, Each Phase: Plus or minus 1 percent.
      2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      4) Megawatts: Plus or minus 2 percent.
      5) Megavars: Plus or minus 2 percent.
      6) Power Factor: Plus or minus 2 percent.
      7) Frequency: Plus or minus 0.5 percent.
      8) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
      9) Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
      10) Contact devices to operate remote impulse-totalizing demand meter.
   b. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
   a. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
   b. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
4. Instrument Switches: Rotary type with off position.
   a. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
   b. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
5. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
6. Watt-Hour Meters and Wattmeters:
   a. Comply with ANSI C12.1.
   b. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
   c. Suitable for connection to three- and four-wire circuits.
   d. Potential indicating lamps.
   e. Adjustments for light and full load, phase balance, and power factor.
   f. Four-dial clock register.
   g. Integral demand indicator.
   h. Contact devices to operate remote impulse-totalizing demand meter.
   i. Ratchets to prevent reverse rotation.
   j. Removable meter with drawout test plug.
   k. Semiflush mounted case with matching cover.
   l. Appropriate multiplier tag.
7. Impulse-Totalizing Demand Meter:
   a. Comply with ANSI C12.1.
   b. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
   c. Cyclometer.
   d. Four-dial, totalizing kilowatt-hour register.
   e. Positive chart drive mechanism.
   f. Capillary pen holding a minimum of one month's ink supply.
   g. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
   h. Capable of indicating and recording five **OR** 15 **OR** 30, **as directed**,-minute integrated demand of totalized system.

E. Control Power
1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer **OR** 120-V ac, supplied from remote branch circuit, **as directed**.
2. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
3. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

F. Accessory Components And Features
1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
2. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
3. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
4. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
5. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

G. Identification
1. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
   a. Nameplate: At least 0.032-inch- (0.813-mm-) thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.
2. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
   a. Nameplate: At least 0.0625-inch- (1.588 mm-) thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.
3. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
4. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
5. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
6. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

1.3 EXECUTION

A. Installation
1. Install switchboards and accessories according to NECA 400 **OR** NEMA PB 2.1, **as directed**.
2. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to switchboards.

3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
4. Comply with mounting and anchoring requirements specified in Division 16 Section "Hangers And Supports For Electrical Systems".
5. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
6. Install filler plates in unused spaces of panel-mounted sections.
7. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
   a. Set field-adjustable switches and circuit-breaker trip ranges.
8. Install spare-fuse cabinet.
9. Comply with NECA 1.

B. Connections
1. Comply with requirements for terminating feeder bus specified in Division 16 Section "Enclosed Bus Assemblies". Drawings indicate general arrangement of bus, fittings, and specialties.
2. Comply with requirements for terminating cable trays specified in Division 16 Section "Cable Trays". Drawings indicate general arrangement of cable trays, fittings, and specialties.

C. Identification
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 16 Section "Electrical Identification".
2. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 16 Section "Electrical Identification".
3. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 16 Section "Electrical Identification".

D. Field Quality Control
1. Acceptance Testing Preparation:
   a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
   b. Test continuity of each circuit.
2. Tests and Inspections:
   a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   c. Perform the following infrared scan tests and inspections and prepare reports:
      1) Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front **OR** front and rear, **as directed**, panels so joints and connections are accessible to portable scanner.
      2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
      3) Instruments and Equipment:

a) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

d. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

3. Switchboard will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

E. Adjusting
1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
2. Set field-adjustable circuit-breaker trip ranges as indicated **OR** as specified in Division 16 Section "Overcurrent Protective Device Coordination", **as directed**.

F. Protection
1. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 16470

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Task	Specification	Specification Description
16471	16101a	Panelboards

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SECTION 16480 - POWER DISTRIBUTION UNITS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for power distribution units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes freestanding, prepackaged, power distribution units for transforming, conditioning, and distributing electrical power.

C. Definitions
1. TVSS: Transient voltage surge suppression.
2. UPS: Uninterrupted power supply.

D. Submittals
1. Product Data: For power distribution units.
2. Shop Drawings: Include dimensioned plans, sections, and elevations. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that power distribution units, accessories, and components will withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and Maintenance Data: For power distribution units to include in emergency, operation, and maintenance manuals.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

F. Delivery, Storage, And Handling
1. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.
2. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and humidity tolerances for non-operating equipment.

1.2 PRODUCTS

A. Manufactured Units
1. Description: Integrated and coordinated assembly of power-line-conditioning and distribution components packaged in a single cabinet or modular assembly of cabinets each with full-swivel casters mounted to bottom frame, **as directed**. Include the following components:
   a. Input-power, circuit-breaker section.
   b. Isolation transformer.
   c. TVSS system.
   d. Output panelboard(s).

e. Alarm, monitoring, and control system.

2. Provide units that are constructed to withstand seismic forces specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

3. Unit Capacity Rating: Unit shall carry indicated rms kilovolt-ampere load continuously without exceeding rated insulation temperature for the following input voltage and load current:

a. Input Voltage: Within rated input-voltage tolerance band of unit.

b. Load Current: Minimum of 3.0 crest factor and 85 percent total harmonic distortion.

B. Input-Power, Circuit-Breaker Section

1. Description: 3-pole, shunt-tripped, thermal-magnetic-type circuit breaker, rated for indicated interrupting capacity and 125 percent of input current of unit at 100 percent rated load.

a. Dual-Input Units:

1) Two input circuit breakers arranged to provide transfer between two input-voltage sources.

2) Controls and interfaces to allow both open- and closed-transition transfer between two input-voltage sources.

3) Use a 120-V permissive signal from both upstream voltage sources to indicate acceptable conditions for closed-transition transfer.

4) Open second circuit breaker automatically after closed-transition transfer is competed.

C. Isolation Transformer Section

1. Description: Dry-type, electrostatically shielded, three-phase, common-core, convection-air-cooled isolation transformer.

a. Comply with UL 1561 including requirements for nonsinusoidal load-current-handling capability defined by designated K-factor, **as directed**.

b. Cores: Grain-oriented, non-aging silicon steel, one leg per phase.

c. Coil Material and Insulation: Copper windings with a 220 deg C insulation class.

d. Temperature Rise: Designed for 80 **OR** 115 **OR** 150, **as directed**, deg C rise above 40 deg C ambient.

e. Output Impedance: 3.5 plus or minus 0.5 percent.

f. Regulation: 2 to 4 percent maximum, at full-resistive load; 5 percent maximum, at rated nonlinear load.

g. Taps: 6 full-capacity compensation taps at 2.5 percent increments; 2 above and 4 below nominal voltage.

h. Full-Load Efficiency: Minimum 96 percent at rated nonlinear, **as directed**, load.

i. Magnetic-Field Strength External to Transformer Enclosure: Less than 0.1 gauss at 450 mm.

j. Audible Noise: Comply with NEMA ST 20.

k. Electrostatic Shielding: Independently shield each winding with a double-copper, electrostatic shield arranged to minimize interwinding capacitance.

1) Coil leads and terminal trips shall be arranged to minimize capacitive coupling between input and output connections.

2) Shield Terminal: Separate, and marked "Shield" for grounding connection.

3) Capacitance: Limit capacitance between primary and secondary windings to a maximum of 33 picofarads over a frequency range of 20 Hz to 1 MHz.

4) Common-Mode Noise Attenuation: 120 dB minimum, 0.5 to 1.5 kHz; minus 65 dB minimum, 1.5 to 100 kHz.

5) Normal-Mode Noise Attenuation: Minus 52 dB minimum, 1.5 to 10 kHz.

l. Neutral Rating: 1.732 times the system full-load ampere rating.

D. TVSS System

1. Description: Integrated TVSS system complying with Division 16 Section "Transient Voltage Suppression", to protect unit panelboard, and having the following features:

a. Disconnect Device: Manual, three-pole, fused disconnect switch to de-energize TVSS system while permitting power distribution units to continue operation. Fuses are rated at 200-kA interrupting capacity.
b. Nonlinear Loading: System shall accommodate rated-load current with a minimum 3.0 crest factor and 85 percent total harmonic distortion.

E. Output Panelboards
1. Description: Panelboards complying with Division 16 Section "Panelboards", except for mounting provisions. Mount in front of power distribution units behind flush doors. Include the following features:
a. Construction: 42 pole, 240 V, 3 phase; capable of accepting branch circuit breakers rated to 100 A.
b. Panelboard Rating: 225 A, with main circuit breaker.
c. Panelboard Phase, Neutral and Ground Buses: Copper, with neutral bus at least 1.732 times the nominal phase bus rating.
d. Isolated Ground Bus: Copper, adequate for branch-circuit equipment ground conductors; insulated from supports.
e. Branch Circuit Breakers: Bolt **OR** Plug, **as directed**, on.
f. Cable Racks: Removable and arranged for supporting and routing cables for panelboard entrance.
g. Access Panels: Arranged so additional branch-circuit wiring can be installed and connected in the future.

F. Power Distribution Unit Controls
1. Include the following control features:
a. Emergency, power-off switch integral with power distribution unit.
b. Emergency, power-off input terminals for connection to remote power-off switch.
c. Over-under alarm shutdown with automatic unit disconnection for the following alarm conditions:
1) High temperature.
2) High and low input or output voltage.
3) Phase loss.
4) Ground fault.
5) Reverse phase rotation.
d. Ground-fault protection with automatic system shutdown.
e. Alarm Contacts: Electrically isolated, Form C (one normally open and one normally closed), summary alarm; contact set shall change state if any monitored function goes into alarm mode.
f. Remote Power-Off Control: Control circuit with connection to shunt trip of power distribution unit main power circuit breaker and terminals for connection to one or more remote power-off, push-button stations.

G. Monitoring, Status, And Alarm Annunciation
1. Description: Microprocessor-based monitoring, status, and alarm annunciation panel mounted flush in front of power distribution unit to provide status display and failure-indicating interface for the following:
a. Power Monitoring:
1) Input Voltage: Line to line, rms.
2) Output Voltage: Line to line, rms.
3) Output Voltage: Line to neutral, rms.
4) Output current.
b. Status Indication: Unit on.
c. Alarm Annunciation:
1) High temperature.
2) High and low input voltage.
3) High and low output voltage.

4) Phase loss.
5) Ground fault.
6) Frequency.
7) Phase rotation.
8) TVSS module failure.

d. Audible Alarm and Silencing Switch: Alarm sounds when alarm indication occurs. Silencing switch shall silence audible alarm but leave visual indication active until failure or other alarm conditions are corrected.

H. Sound Level
1. General: Fully assembled products comply with minimum sound-level requirements in NEMA ST 20 for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.
2. General: Fully assembled products have a minimum of 3 dB less than the maximum sound levels prescribed for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.

I. Finishes
1. Manufacturer's standard finish over corrosion-resistant pretreatment and primer.

J. Source Quality Control
1. Factory Tests: Design and routine tests shall comply with referenced standards.
2. Factory Sound-Level Tests: Conduct sound-level tests on equipment. Comply with IEEE C57.12.91 and NEMA ST 20.

1.3 EXECUTION

A. Installation
1. Arrange power distribution units to provide adequate access to equipment and circulation of cooling air.
2. Anchor or restrain floor-mounting power distribution units according to manufacturer's written instructions, seismic codes applicable to Project, **as directed**, and requirements in Division 16 Section "Hangers And Supports For Electrical Systems".
3. Identify equipment and install warning signs according to Division 16 Section "Electrical Identification".

B. Connections
1. Ground equipment according to Division 16 Section "Grounding And Bonding".
a. Separately Derived Systems: Make grounding connections to grounding electrodes as indicated; comply with NFPA 70.
2. Connect wiring according to Division 16 Section "Conductors And Cables".

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification for circuit breakers, molded case; and for transformers, dry type, air cooled, low voltage, small. Certify compliance with test parameters.
b. Perform functional tests of power distribution units throughout their operating ranges. Test each monitoring, status, and alarm function.
c. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of conductor and bus connections.

1) Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
2) Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Substantial Completion.
3) Prepare a certified report identifying connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

3. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

D. Adjusting
1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
2. Adjust power distribution units to provide optimum voltage to equipment served throughout normal operating cycle of loads served. Record input and output voltages and adjustment settings, and incorporate into test results.

E. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16480

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SECTION 16501 - REMOVAL OF FLUORESCENT LIGHT BALLASTS/CAPACITORS AND FLUORESCENT LIGHT TUBES

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for removal of fluorescent light ballasts/capacitors and fluorescent light tubes. Products shall be as follows or as directed by the the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Before Start of Work: Submit the following to the Owner's Representative for review. Do not start work until these submittals are returned with Owner's Representative's approval.
   a. Copy of State or local license for hazardous waste hauler;
   b. Certification of at least one on-site supervisor which has satisfactorily completed the OSHA 40 Hour Health and Safety Course for Handling Hazardous Materials;
   c. Certificates of workers which have successfully completed at least the OSHA 40-Hour Health and Safety Course for Hazardous Materials;
   d. List of employees scheduled to perform this work;
   e. Schedule of start and finish times and dates for this work;
   f. Name and address of landfill where these waste materials are to be deposited (include contact person and telephone numbers);
   g. Material Safety Data Sheets for all materials requiring removal;
   h. If contractor introduces any chemical into the work environmental, a MSDS for that chemical is required before use;
   i. Transporter must have notified the EPA and/or the appropriate local government agency in advance of its intentions to transport PCB's, mercury and cadmium, and receive an identification number pursuant to the Toxic Substance Control Act (TSCA); and
   j. Contingency Plan for handling emergency spills or leaks.

1.2 PRODUCTS

A. Materials

1. Polyethylene Sheet: A single polyethylene film in the largest sheet size possible to minimize seams, 4.0 and 6.0 mil thick, clear, frosted, or black.
2. Duct Tape: Provide duct tape in 3" widths, witty an adhesive which is formulated to stick aggressively to sheet polyethylene.
3. Spray Cement: Provide spray adhesive in aerosol cans which is specifically formulated to stick tenaciously to sheet polyethylene.
4. Disposal Bays: Provide 6 mil thick leak-tight polyethylene bags.
5. Labels: As required by the EPA and OSHA for handling, transportation, and disposal of hazardous waste.
6. **Drums:** Recovery or salvage drums acceptable for disposal of hazardous waste. Prior approval of drums is required. Drums or containers must meet the required OSHA EPA (40 CFR Parts 264-265 and 300), and DOT regulations (49 CFR Parts 171-178). Use of damaged drums will not be allowed.

1.3 EXECUTION

A. General

1. Where necessary, scaffolding shall be erected to fully access all applicable fluorescent light ballasts/capacitors and tubes. At no time will the ballasts/capacitors and tubes be allowed to drop onto the floor. Contractor must take care to protect from dropping the ballasts/capacitors and fluorescent tubes.
2. Prior to removing ballasts/capacitors and fluorescent tubes, contractor shall ensure that all electrical service to lights has been shut off, and locked out. Temporary lighting shall be erected to adequately illuminate work areas.
3. Depending on height of light fixtures, contractor shall utilize at least a 2-person per team system. The fluorescent light tubes shall be removed and passed to the appropriate number of workers required to lower the tubes to the floor without breaking them.
4. The worker on the floor shall lay the tubes in cardboard boxes large enough to hold a small quantity of tubes. Worker shall take care to not damage the tubes while they are lowered into the box. Once the box is full, it shall be wrapped with two layers of 6 mil thick polyethylene sheeting and sealed with duct tape.
5. Contractor may choose to either remove the fluorescent light ballasts/capacitors in-place or lower the lighting fixtures for easy access. The ballasts/capacitors shall be removed from the fixtures. Electrical wiring leading from the ballasts/capacitors shall be cut away. Ballasts/capacitors shall be placed in 55-gallon drums lined with at least two 6 mil thick polyethylene bags. Be careful not to overfill the drums so that they remain manageable. Once the drums have been filled to the acceptable level, seal the lid onto the top of the drum, and affix appropriate labels. Transport drums via hand dollies.

B. Worker Protection
1. As a minimum, while working with the ballasts/capacitors and light tubes, workers shall utilize impervious gloves adequate for the use with hazardous materials. If light ballasts/capacitors and/or light tubes are damaged, and/or exposure to these materials may reach the OSHA PEL or AGGIH threshold limit value (TLV), the contractor shall be required to provide impervious full body protection and respiratory protection. However, contractor is required to verify the type of protection required prior to working with these materials, and have written approval by Owner's Representative prior to beginning.
2. In addition, workers shall not smoke, drink or eat in these areas during work activities.

C. Storage Of Fluorescent Light Ballasts/Capacitors And Light Tubes
1. Once the containers holding the ballasts/capacitors and light tubes have been filled and sealed, they shall be stored in designated areas as agreed upon by the Owners Representative and Contractor. They shall not be allowed to be stored on-site in transportation vehicles until the time for them to be transported to the hazardous waste incinerators or landfill facility.

END OF SECTION 16501

SECTION 16501a - INTERIOR LIGHTING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for interior lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Interior lighting fixtures, lamps, and ballasts.
b. Emergency lighting units.
c. Exit signs.
d. Lighting fixture supports.
e. Retrofit kits for fluorescent lighting fixtures.

C. Definitions
1. BF: Ballast factor.
2. CCT: Correlated color temperature.
3. CRI: Color-rendering index.
4. HID: High-intensity discharge.
5. LER: Luminaire efficacy rating.
6. Lumen: Measured output of lamp and luminaire, or both.
7. Luminaire: Complete lighting fixture, including ballast housing if provided.

D. Submittals
1. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
a. Physical description of lighting fixture including dimensions.
b. Emergency lighting units including battery and charger.
c. Ballast, including BF.
d. Energy-efficiency data.
e. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 15 Section "Diffusers, Registers, And Grilles".
f. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 15 Section "Diffusers, Registers, And Grilles".
g. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
h. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
1) Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
OR
Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
2. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.

a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
b. Wiring Diagrams: For power, signal, and control wiring.

3. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:
   a. Lamps and ballasts, installed.
   b. Cords and plugs.
   c. Pendant support system.
4. Installation instructions.
5. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   a. Lighting fixtures.
   b. Suspended ceiling components.
   c. Partitions and millwork that penetrate the ceiling or extends to within 12 inches (305 mm) of the plane of the luminaires.
   d. Ceiling-mounted projectors.
   e. Structural members to which suspension systems for lighting fixtures will be attached.
   f. Other items in finished ceiling including the following:
      1) Air outlets and inlets.
      2) Speakers.
      3) Sprinklers.
      4) Smoke and fire detectors.
      5) Occupancy sensors.
      6) Access panels.
   g. Perimeter moldings.
6. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
7. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
8. Field quality-control reports.
9. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
   a. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.
10. Warranty: Sample of special warranty.

E. Quality Assurance
1. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
   OR
   Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.
4. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. Coordination
1. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

G. Warranty
1. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
   a. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
   b. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

1.2 PRODUCTS

A. General Requirements For Lighting Fixtures And Components
1. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
2. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
3. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
4. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.
5. Metal Parts: Free of burrs and sharp corners and edges.
6. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
7. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
8. Diffusers and Globes:
   a. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
      1) Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.
      2) UV stabilized.
   b. Glass: Annealed crystal glass unless otherwise indicated.
9. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
   a. Label shall include the following lamp and ballast characteristics:
      1) "USE ONLY" and include specific lamp type.
      2) Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
      3) Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
      4) Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
      5) ANSI ballast type (M98, M57, etc.) for HID luminaires.
      6) CCT and CRI for all luminaires.
10. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.
11. Air-Handling Fluorescent Fixtures: For use with plenum ceiling for air return and heat extraction and for attaching an air-diffuser-boot assembly specified in Division 15 Section "Diffusers, Registers, and Grilles."
   a. Air-Supply Units: Slots in one or both side trims join with air-diffuser-boot assemblies.

b. Heat-Removal Units: Air path leads through lamp cavity.
c. Combination Heat-Removal and Air-Supply Unit: Heat is removed through lamp cavity at both ends of the fixture door with air supply same as for air-supply units.
d. Dampers: Operable from outside fixture for control of return-air volume.
e. Static Fixture: Air-supply slots are blanked off, and fixture appearance matches active units.

B. Ballasts For Linear Fluorescent Lamps
1. General Requirements for Electronic Ballasts:
a. Comply with UL 935 and with ANSI C82.11.
b. Designed for type and quantity of lamps served.
c. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
d. Sound Rating: Class A **OR** Class A except Class B for T12/HO and T12/Slimline lamp ballasts, **as directed**.
e. Total Harmonic Distortion Rating: Less than 10 **OR** 20, **as directed**, percent.
f. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
g. Operating Frequency: 42 kHz or higher.
h. Lamp Current Crest Factor: 1.7 or less.
i. BF: 0.88 or higher.
j. Power Factor: 0.95 **OR** 0.98, **as directed**, or higher.
k. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
2. Luminaires controlled by occupancy sensors shall have programmed-start ballasts.
3. Electronic Programmed-Start Ballasts for T5 **OR** T8 **OR** T5HO **OR** T5 and T5HO, **as directed**, Lamps: Comply with ANSI C82.11 and the following:
a. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
b. Automatic lamp starting after lamp replacement.
4. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
a. Ballast Manufacturer Certification: Indicated by label.
5. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
6. Ballasts for Low-Temperature Environments:
a. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic or electromagnetic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
b. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
7. Ballasts for Residential Applications: Fixtures designated as "Residential" may use low-power-factor electronic ballasts having a Class B sound rating and total harmonic distortion of approximately 30 percent.
8. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
9. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
a. Dimming Range: 100 to 5 percent of rated lamp lumens.
b. Ballast Input Watts: Can be reduced to 20 percent of normal.
c. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
d. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.
10. Ballasts for Bi-Level Controlled Lighting Fixtures: Electronic type.

a. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
   1) High-Level Operation: 100 percent of rated lamp lumens.
   2) Low-Level Operation: 30 percent of rated lamp lumens.
b. Ballast shall provide equal current to each lamp in each operating mode.
c. Compatibility: Certified by manufacturer for use with specific bi-level control system and lamp type indicated.

11. Ballasts for Tri-Level Controlled Lighting Fixtures: Electronic type.
   a. Operating Modes: Ballast circuit and leads provide for remote control of the light output of the associated lamp between high- and low-level and off.
      1) High-Level Operation: 100 percent of rated lamp lumens.
      2) Low-Level Operation: 30 and 50 **OR** 30 and 60, **as directed**, percent of rated lamp lumens.
   b. Ballast shall provide equal current to each lamp in each operating mode.
   c. Compatibility: Certified by manufacturer for use with specific tri-level control system and lamp type indicated.

C. Ballasts For Compact Fluorescent Lamps
1. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
   a. Lamp end-of-life detection and shutdown circuit.
   b. Automatic lamp starting after lamp replacement.
   c. Sound Rating: Class A.
   d. Total Harmonic Distortion Rating: Less than 20 percent.
   e. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
   f. Operating Frequency: 20 kHz or higher.
   g. Lamp Current Crest Factor: 1.7 or less.
   h. BF: 0.95 or higher unless otherwise indicated.
   i. Power Factor: 0.95 **OR** 0.98, **as directed**, except fixtures designated as "Residential" may use low-power-factor electronic ballasts, **as directed**, or higher.
   j. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

D. Emergency Fluorescent Power Unit
1. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
   a. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
   b. Nightlight Connection: Operate one fluorescent lamp continuously.
   c. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
      1) Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
      2) Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   d. Battery: Sealed, maintenance-free, nickel-cadmium type.
   e. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
   f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more fluorescent lamps, remote mounted from lighting fixture. Comply with UL 924.
   a. Emergency Connection: Operate one fluorescent lamp continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
   b. Nightlight Connection: Operate one fluorescent lamp in a remote fixture continuously.
   c. Battery: Sealed, maintenance-free, nickel-cadmium type.
   d. Charger: Fully automatic, solid-state, constant-current type.
   e. Housing: NEMA 250, Type 1 enclosure.
   f. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   g. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   h. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
   i. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

E. Ballasts For HID Lamps
1. Electromagnetic Ballast for Metal-Halide Lamps: Comply with ANSI C82.4 and UL 1029. Include the following features unless otherwise indicated:
   a. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
   b. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C) for single-lamp ballasts.
   c. Rated Ambient Operating Temperature: 104 deg F (40 deg C).
   d. Open-circuit operation that will not reduce average life.
   e. Low-Noise Ballasts: Manufacturers' standard epoxy-encapsulated models designed to minimize audible fixture noise.
2. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:
   a. Minimum Starting Temperature: Minus 20 deg F (Minus 29 deg C) for single-lamp ballasts.
   b. Rated Ambient Operating Temperature: 130 deg F (54 deg C).
   c. Lamp end-of-life detection and shutdown circuit.
   d. Sound Rating: Class A.
   e. Total Harmonic Distortion Rating: Less than 20 percent.
   f. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
   g. Lamp Current Crest Factor: 1.5 or less.
   h. Power Factor: 0.90 or higher.
   i. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
   j. Protection: Class P thermal cutout.
   k. Bi-Level Dimming Ballast: Ballast circuit and leads provide for remote control of the light output of the associated fixture between high- and low-level and off.
      1) High-Level Operation: 100 percent of rated lamp lumens.
      2) Low-Level Operation: 35 **OR** 50, **as directed**, percent of rated lamp lumens.
      3) Compatibility: Certified by ballast manufacturer for use with specific bi-level control system and lamp type indicated. Certified by lamp manufacturer that ballast operating modes are free from negative effect on lamp life and color-rendering capability.
   l. Continuous Dimming Ballast: Dimming range shall be from 100 to 35 percent of rated lamp lumens without flicker.

1) Ballast Input Watts: Reduced to a maximum of 50 percent of normal at lowest dimming setting.

3. High-Pressure Sodium Ballasts: Electromagnetic type, with solid-state igniter/starter. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
   a. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
   b. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).

F. Quartz Lamp Lighting Controller
1. General Requirements for Controllers: Factory installed by lighting fixture manufacturer. Comply with UL 1598.
2. Standby (Quartz Restrike): Automatically switches quartz lamp on when a HID lamp in the fixture is initially energized and during the HID lamp restrike period after brief power outages.
3. Connections: Designed for a single branch -circuit connection.
4. Switching Off: Automatically switches quartz lamp off when HID lamp strikes.
   OR
   Switching Off: Automatically switches quartz lamp off when HID lamp reaches approximately 60 percent light output.

G. Exit Signs
1. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
2. Internally Lighted Signs:
   a. Lamps for AC Operation: Fluorescent, two for each fixture, 20,000 hours of rated lamp life.
      OR
      Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
   b. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
      1) Battery: Sealed, maintenance-free, nickel-cadmium type.
      2) Charger: Fully automatic, solid-state type with sealed transfer relay.
      3) Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
      4) Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
      5) LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
      6) Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
      7) Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
   c. Master/Remote Sign Configurations:
      1) Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply **OR** ballast **OR** battery, **as directed**, for power connection to remote unit.
      2) Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

3. Self-Luminous Signs: Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for 10 **OR** 15 **OR** 20, **as directed**, years.
   OR
   Self-Luminous Signs: Using strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Provide with universal bracket for flush-ceiling, wall, or end mounting.

H. Emergency Lighting Units
1. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
   a. Battery: Sealed, maintenance-free, lead-acid type.
   b. Charger: Fully automatic, solid-state type with sealed transfer relay.
   c. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
   d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
   e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
   f. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
   g. Integral Time-Delay Relay: Holds unit on for fixed interval of 15 minutes when power is restored after an outage.
   h. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
   i. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

I. Fluorescent Lamps
1. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life 20,000 hours unless otherwise indicated.
2. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500 K, and average rated life of 20,000 hours unless otherwise indicated.
3. T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000 K, and average rated life of 20,000 hours unless otherwise indicated.
4. T5HO rapid-start, high-output lamps, rated 54 W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100 K, and average rated life of 20,000 hours unless otherwise indicated.
5. Compact Fluorescent Lamps: 4-Pin, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at three hours operation per start, and suitable for use with dimming ballasts, **as directed**, unless otherwise indicated.
   a. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
   b. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
   c. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
   d. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
   e. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).
   f. 57 W: T4, triple tube, rated 4300 initial lumens (minimum).

g. 70 W: T4, triple tube, rated 5200 initial lumens (minimum).

J. HID Lamps
1. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), color temperature 1900 K, and average rated life of 24,000 hours, minimum.
   a. Dual-Arc Tube Lamps: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
2. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and color temperature 4000 K.
3. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000 K.
4. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and color temperature 4000 K.
5. Low-Pressure Sodium Lamps: ANSI 78.41, CRI 0, and color temperature 1800 K.

K. Lighting Fixture Support Components
1. Comply with Division 16 Section "Hangers And Supports For Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
2. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
3. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
4. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
5. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
6. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
7. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

L. Retrofit Kits For Fluorescent Lighting Fixtures
1. Reflector Kit: UL 1598, Type I. Suitable for two- to four-lamp, surface-mounted or recessed lighting fixtures by improving reflectivity of fixture surfaces.
2. Ballast and Lamp Change Kit: UL 1598, Type II. Suitable for changing existing ballast, lamps, and sockets.

1.3 EXECUTION

A. Installation
1. Lighting fixtures:
   a. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
   b. Install lamps in each luminaire.
2. Temporary Lighting: If it is necessary, and approved by the Owner, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
3. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.
4. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
   a. Install ceiling support system rods or wires, independent of the ceiling suspension devices, **as directed**, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
   b. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   c. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.

d. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

5. Suspended Lighting Fixture Support:
   a. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
   b. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
   c. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
   d. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
6. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
7. Connect wiring according to Division 16 Section "Conductors And Cables".

B. Identification
1. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 16 Section "Electrical Identification".

C. Field Quality Control
1. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
2. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
3. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

D. Startup Service
1. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

E. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
   a. Adjust aimable luminaires in the presence of the Owner.

END OF SECTION 16501a

Task	Specification	Specification Description
16501	16521	Exterior Lighting
16502	16501	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
16502	16501a	Interior Lighting
16502	16521	Exterior Lighting
16505	16501a	Interior Lighting
16510	01352	No Specification Required
16510	16501a	Interior Lighting

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SECTION 16521 - EXTERIOR LIGHTING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for exterior lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Exterior luminaires with lamps and ballasts.
b. Luminaire-mounted photoelectric relays.
c. Poles and accessories.
d. Luminaire lowering devices.

C. Definitions
1. CCT: Correlated color temperature.
2. CRI: Color-rendering index.
3. HID: High-intensity discharge.
4. LER: Luminaire efficacy rating.
5. Luminaire: Complete lighting fixture, including ballast housing if provided.
6. Pole: Luminaire support structure, including tower used for large area illumination.
7. Standard: Same definition as "Pole" above.

D. Structural Analysis Criteria For Pole Selection
1. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
2. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4-M.
3. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.
4. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.
a. Basic wind speed for calculating wind load for poles exceeding 49.2 feet (15 m) in height is 100 mph (45 m/s) **OR** 90 mph (40 m/s), **as directed**.
1) Wind Importance Factor: 1.0.
2) Minimum Design Life: 50 years.
3) Velocity Conversion Factors: 1.0.
b. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s) **OR** 90 mph (40 m/s).
1) Wind Importance Factor: 1.0.
2) Minimum Design Life: 25 years.
3) Velocity Conversion Factors: 1.0.

E. Submittals
1. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
a. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
b. Details of attaching luminaires and accessories.
c. Details of installation and construction.
d. Luminaire materials.
e. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

1) Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
OR
Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

f. Photoelectric relays.
g. Ballasts, including energy-efficiency data.
h. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
i. Materials, dimensions, and finishes of poles.
j. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
k. Anchor bolts for poles.
l. Manufactured pole foundations.

2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
   c. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
   d. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.
4. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.
5. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
6. Field quality-control reports.
7. Operation and Maintenance Data: For luminaires and poles **OR** luminaire lowering devices, **as directed**, to include in emergency, operation, and maintenance manuals.
8. Warranty: Sample of special warranty.

F. Quality Assurance
1. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
OR
Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with IEEE C2, "National Electrical Safety Code."
4. Comply with NFPA 70.

G. Delivery, Storage, And Handling
1. Package aluminum poles for shipping according to ASTM B 660.
2. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
3. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.

4. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
5. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
   a. Warranty Period for Luminaires: Five years from date of Substantial Completion.
   b. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
   c. Warranty Period for Color Retention: Five years from date of Substantial Completion.
   d. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

1.2 PRODUCTS

A. General Requirements For Luminaires
1. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
   a. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
   b. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
   c. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.
2. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
3. Metal Parts: Free of burrs and sharp corners and edges.
4. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
5. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
6. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
7. Exposed Hardware Material: Stainless steel.
8. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
9. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
10. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
    a. White Surfaces: 85 percent.
    b. Specular Surfaces: 83 percent.
    c. Diffusing Specular Surfaces: 75 percent.
11. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
12. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
13. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

a. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."

b. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

1) Color: As selected from manufacturer's standard catalog of colors **OR** As selected from manufacturer's full range, **as directed**.

14. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

a. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

b. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

c. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.

d. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

1) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black, **as directed**.

15. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

a. Label shall include the following lamp and ballast characteristics:

1) "USES ONLY" and include specific lamp type.

2) Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.

3) Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

4) Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.

5) ANSI ballast type (M98, M57, etc.) for HID luminaires.

6) CCT and CRI for all luminaires.

B. Luminaire-Mounted Photoelectric Relays

1. Comply with UL 773 or UL 773A.

2. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff, **as directed**.

a. Relay with locking-type receptacle shall comply with ANSI C136.10.

b. Adjustable window slide for adjusting on-off set points.

C. Fluorescent Ballasts And Lamps

1. Ballasts for Low-Temperature Environments:

a. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: Electronic or electromagnetic type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.

b. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.

2. Ballast Characteristics:

a. Power Factor: 90 percent, minimum.

b. Sound Rating: Class A **OR** Class A except Class B for T12/HO ballasts, **as directed**.
c. Total Harmonic Distortion Rating: Less than 10 **OR** 20, **as directed**, percent.
d. Electromagnetic Ballasts: Comply with ANSI C82.1, energy-saving, high power factor, Class P, automatic-reset thermal protection.
e. Case Temperature for Compact Lamp Ballasts: 65 deg C, maximum.
f. Transient-Voltage Protection: Comply with IEEE C62.41.1 and IEEE C62.41.2, Category A or better.

3. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures 0 deg F (minus 18 deg C) **OR** minus 20 deg F (minus 29 deg C), **as directed**, and higher.

D. Ballasts For HID Lamps
1. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features unless otherwise indicated:
a. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
b. Minimum Starting Temperature: Minus 22 deg F (Minus 30 deg C).
c. Normal Ambient Operating Temperature: 104 deg F (40 deg C).
d. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.
2. Auxiliary, Instant-On, Quartz System: Factory-installed feature automatically switches quartz lamp on when fixture is initially energized and when momentary power outages occur. System automatically turns quartz lamp off when HID lamp reaches approximately 60 percent of light output.
3. High-Pressure Sodium Ballasts: Electromagnetic type with solid-state igniter/starter and capable of open-circuit operation without reduction of average lamp life. Igniter/starter shall have an average life in pulsing mode of 10,000 hours at an igniter/starter-case temperature of 90 deg C.
a. Instant-Restrike Device: Integral with ballast, or solid-state potted module, factory installed within fixture and compatible with lamps, ballasts, and mogul sockets up to 150 W.
1) Restrike Range: 105- to 130-V ac.
2) Maximum Voltage: 250-V peak or 150-V ac rms.
b. Minimum Starting Temperature: Minus 40 deg F (Minus 40 deg C).

E. HID Lamps
1. High-Pressure Sodium Lamps: ANSI C78.42, CRI 21 (minimum), CCT color temperature 1900 K, and average rated life of 24,000 hours, minimum.
a. Dual-Arc Tube Lamp: Arranged so only one of two arc tubes is lighted at one time and, when power is restored after an outage, the cooler arc tube, with lower internal pressure, lights instantly, providing an immediate 8 to 15 percent of normal light output.
2. Low-Pressure Sodium Lamps: ANSI C78.43.
3. Metal-Halide Lamps: ANSI C78.43, with minimum CRI 65, and CCT color temperature 4000 K.
4. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and CCT color temperature 4000 K.
5. Ceramic, Pulse-Start, Metal-Halide Lamps: Minimum CRI 80, and CCT color temperature 4000 K.

F. General Requirements For Poles And Support Components
1. Structural Characteristics: Comply with AASHTO LTS-4-M.
a. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
b. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
2. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
3. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

a. Materials: Shall not cause galvanic action at contact points.
b. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
c. Anchor-Bolt Template: Plywood or steel.

4. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws. Provide on all, except wood poles.
5. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 3 Section "Cast-in-Place Concrete."
6. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
7. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

G. Steel Poles

1. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
   a. Shape: Round, tapered **OR** Round, straight **OR** Square, tapered **OR** Square, straight, **as directed**.
   b. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
2. Steel Mast Arms: Single-arm **OR** Truss **OR** Davit, **as directed**, type, continuously welded to pole attachment plate. Material and finish same as pole.
3. Brackets for Luminaires: Detachable, cantilever, without underbrace.
   a. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless **OR** galvanized, **as directed**,-steel bolts.
   b. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
   c. Match pole material and finish.
4. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
5. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
6. Intermediate Handhole and Cable Support: Weathertight, 3-by-5-inch (76-by-127-mm) handhole located at midpoint of pole with cover for access to internal welded attachment lug for electric cable support grip.
7. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 16 Section "Grounding And Bonding", listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
8. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
9. Platform for Lamp and Ballast Servicing: Factory fabricated of steel with finish matching that of pole.
10. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
11. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
12. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
    a. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
    b. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

c. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
   1) Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range, **as directed**.

H. Aluminum Poles
1. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
2. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
   a. Shape: Round, tapered **OR** Round, straight **OR** Square, tapered **OR** Square, straight, **as directed**.
   b. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
3. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
4. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Division 16 Section "Grounding And Bonding", listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
5. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
   a. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
   b. Finish: Same as pole **OR** luminaire, **as directed**.
6. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
7. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
   a. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
   b. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
   c. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
   d. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
      1) Color: Light bronze **OR** Medium bronze **OR** Dark bronze **OR** Black **OR** As selected from manufacturer's full range, **as directed**.

I. Fiberglass Poles
1. Poles: Designed specifically for supporting luminaires, with factory-formed cable entrance and handhole. Not less than 65 percent fiberglass, with resin and pigment making up the remainder.
   a. Resin Color: Dark bronze; provide uniform coloration throughout entire wall thickness.
   b. Surface Finish: Pigmented polyurethane, with a minimum dry film thickness of 1.5 mils (0.04 mm). Polyurethane may be omitted if the surface layer of pole is inherently UV inhibited.

J. Decorative Poles
1. Pole Material:
   a. Cast ductile iron.
   b. Cast gray iron, according to ASTM A 48/A 48M, Class 30.
   c. Cast aluminum.
   d. Cast concrete.
   e. Spun concrete.
   f. Steel tube, covered with closed-cell polyurethane foam, with a polyethylene exterior.
2. Mounting Provisions:

a. Bolted to concrete foundation.
b. Embedded.

3. Fixture Brackets:
   a. Cast ductile iron.
   b. Cast gray iron.
   c. Cast aluminum.
4. Pole Finish: <**Insert finish**>.

K. Laminated Wood Poles
1. Species and Grades for Structural Glulam Timber: Engineer and fabricate structural laminated wood poles, complying with ANSI A190.1. Use southern pine **OR** Douglas fir **OR** Alaska cedar **OR** any species listed in AITC 117, **as directed**, to withstand indicated structural loads without exceeding allowable design working stresses according to AITC 117.
2. Features: Include wood bracket **OR** wood crossarm **OR** pole-top adapter, **as directed**, for mounting luminaire(s), metal pole cap, **as directed**, and concealed raceway path connected to access handhole.
3. Mounting Provisions: Embedded.
4. Appearance Grade: Architectural appearance grade complying with AITC 110.
5. Preservative Treatment: Pressure treat lumber before gluing according to AWPA C28 for waterborne preservatives. After dressing and end-cutting each member to final size and shape, apply a field-treatment preservative to comply with AWPA M4 to surfaces cut to a depth of more than 1/16 inch (1.6 mm).
6. Adhesive: Wet-use type complying with ASTM D 2559.
7. End Sealer: Manufacturer's standard, transparent, colorless wood sealer that is effective in retarding the transmission of moisture at cross-grain cuts and is compatible with indicated finish.
8. Penetrating Sealer: Manufacturer's standard, transparent, penetrating wood sealer that is compatible with indicated finish.
9. Finish: Natural, unstained wood **OR** Semitransparent stain applied after erection **OR** Semitransparent stain applied at factory, **as directed**, color as selected.

L. Wood Poles
1. Poles: Douglas fir **OR** Southern yellow pine, **as directed**, machine trimmed by turning, **as directed**, complying with ANSI O5.1 and with AWPA C4 for wood species used; and bored, roofed, and gained before treatment.
   a. Mounting Provisions: Embedded.
2. Preservative Treatment: Pressure treat poles with creosote **OR** pentachlorophenol **OR** ammoniacal copper arsenate, **as directed**, according to AWPA C1 and AWPA C4.
3. Luminaire Brackets: Comply with ANSI C136.13.

M. Prestressed Concrete Poles
1. Poles: Manufactured by centrifugal spin-casting process **OR** of cast concrete, **as directed**.
   a. Shape: Round, tapered **OR** Round, straight **OR** Square, tapered **OR** Square, straight, **as directed**.
   b. Mounting Provisions: Steel butt flange for bolted mounting to foundation or breakaway support **OR** Embedded, **as directed**.
   c. Finishing: Capped at top and plugged at bottom. Seat each steel reinforcing strand with epoxy adhesive.
   d. Grounding: Continuous copper ground wire cast into pole. Terminate at top of pole and attach to 24-inch (610-mm) lightning rod, **as directed**.
2. Cure with wet steam and age for a minimum of 15 days before installation.
3. Fabricate poles with a hard, nonporous surface that is resistant to water, frost, and road and soil chemicals and that has a maximum water-absorption rate of 3 percent.
4. Cast aluminum nameplate into pole wall at approximately 5 feet (1.5 m) above ground line, listing name of manufacturer, Project identifier, overall height, and approximate weight.
5. Pole Brackets: Comply with ANSI C136.13.

6. Finish Color: Provided by color material complying with ASTM C 979, uniformly impregnated throughout the pole concrete. Color material shall provide a uniform, stable, permanent color and be as follows:
   a. Inert, and carbon free.
   b. Unaffected by environmental conditions and contaminants including, but not limited to, UV solar radiation, salts, and alkalis.
7. Finish Texture: Standard form **OR** Polished exposed aggregate **OR** Etched exposed aggregate, **as directed**.
   a. Exposed aggregate shall be of <**Insert aggregate type selected from manufacturers' lists**> type.

N. Pole Accessories
1. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 16 Section "Wiring Devices" for ground-fault circuit-interrupter type.
   a. Surface mounted **OR** Recessed, **as directed**, 12 inches (300 mm) above finished grade.
   b. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, that when mounted results in NEMA 250, Type 3R **OR** Type 4X, **as directed**, enclosure.
   c. With cord opening.
   d. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
2. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
3. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
4. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballast(s) **OR** indicated accessories, **as directed**.
5. Decorative accessories, supplied by decorative pole manufacturer, include the following:
   a. Banner Arms: <**Insert material**>.
   b. Flag Holders: <**Insert material**>.
   c. Ladder Rests: <**Insert material**>.

O. Lowering System For Luminaires
1. Arrange system to lower luminaire **OR** luminaire assembly, **as directed**, to a servicing position within 36 inches (900 mm) of finished grade in winds up to 30 mph (49 km/h) and to provide for manual plug connection to electrical power in the lowered position for testing.
2. Coordinate with luminaire and pole manufacturers for assembly details, wind-load and vibration analysis, and compatibility of materials for electrolysis-free attachment and connection for luminaire mounting assembly, lowering device, lowering cable, and portable winch.
3. Structural and Mechanical Design: Use a minimum safety factor of 5.0 for static and dynamic loads of load-bearing components, including cable.
4. Luminaire Mounting and Disconnect Arrangement: Multiple ring **OR** carriage, **as directed**,-mounted luminaires, arranged for lowering and rising as a group.
   a. Electrical cable for normal operating power to luminaires manually disconnects inside pole base, using weatherproof multipin connector, and shall be arranged to move within the pole during lowering and rising of luminaire assembly.
      OR
      Electrical cable for normal operating power to luminaires automatically disconnects at a weatherproof multipin connector within the pole-top lowering head at the beginning of the lowering cycle and reconnects when luminaire or luminaire assembly is raised to the operating position.
5. Lowering Device: Weatherproof, cast-aluminum housing and multiple mechanical latches. Moving parts of latching assembly shall be located in the portion of the unit that is lowered to the servicing position. Positive latching in the operating position shall be indicated to the operator at the base of the pole by a clear visual signal, or by other means acceptable to Owner or authorities having jurisdiction.
6. Lowering Cable: Zinc-electroplated- or stainless-steel aircraft cable.
7. Portable Winch: Manual **OR** 120-V electric, **as directed**, type. One required.
   a. Winch Power Connection: Cord and plug.

b. Winch Raise-Lower Control: Remote-control station with 15 feet (5 m) of cable.

8. Winch Transformer: Portable, totally enclosed, encapsulated, single-phase, dry type. Primary rated at lighting-circuit voltage; secondary rated at 120 V. Permanent, primary and secondary, twist-locking plug connectors on pigtails shall match pole-base power outlet and winch plug.

1.3 EXECUTION

A. Luminaire Installation

1. Install lamps in each luminaire.
2. Fasten luminaire to indicated structural supports.
   a. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
3. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation, **as directed**.

B. Pole Installation

1. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
2. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
   a. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
   b. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
   c. Trees: 15 feet (5 m) from tree trunk.
3. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
   a. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
   b. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
   c. Install base covers unless otherwise indicated.
   d. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
5. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
   a. Dig holes large enough to permit use of tampers in the full depth of hole.
   b. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
6. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
   a. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
   b. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
   c. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
   d. Cure concrete a minimum of 72 hours before performing work on pole.
7. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.
8. Raise and set poles using web fabric slings (not chain or cable).

C. Bollard Luminaire Installation
   1. Align units for optimum directional alignment of light distribution.
   2. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-place Concrete".

D. Installation Of Individual Ground-Mounting Luminaires
   1. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-place Concrete".

E. Corrosion Prevention
   1. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
   2. Steel Conduits: Comply with Division 16 Section "Raceways And Boxes". In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

F. Grounding
   1. Ground metal poles and support structures according to Division 16 Section "Grounding And Bonding".
      a. Install grounding electrode for each pole unless otherwise indicated.
      b. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
   2. Ground nonmetallic poles and support structures according to Division 16 Section "Grounding And Bonding".
      a. Install grounding electrode for each pole.
      b. Install grounding conductor and conductor protector.
      c. Ground metallic components of pole accessories and foundations.

G. Field Quality Control
   1. Inspect each installed fixture for damage. Replace damaged fixtures and components.
   2. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
      a. Verify operation of photoelectric controls.
   3. Illumination Tests:
      a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):
         1) IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
         2) IESNA LM-50, "Photometric Measurements of Roadway Lighting Installations."
         3) IESNA LM-52, "Photometric Measurements of Roadway Sign Installations."
         4) IESNA LM-64, "Photometric Measurements of Parking Areas."
         5) IESNA LM-72, "Directional Positioning of Photometric Data."
   4. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

H. Demonstration
   1. Train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.

END OF SECTION 16521

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Task	Specification	Specification Description
16521	01352	No Specification Required
16522	16521	Exterior Lighting
16530	16501a	Interior Lighting

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SECTION 16555 - STAGE LIGHTING

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for stage lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Dimmer racks.
b. Control console and control devices.
c. Lighting fixtures and accessories.
d. Distribution components.

C. Performance Requirements
1. Seismic Performance: Dimmer racks shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

D. Submittals
1. Product Data: For each type of product indicated.
2. Seismic Qualification Certificates: For <**Insert equipment,**> accessories, and components, from manufacturer.
3. Field quality-control reports.
4. Operation and maintenance data.
5. Software and Firmware Operational Documentation.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NECA 1.
3. Comply with NFPA 70.

F. Software Service Agreement (if allowed)
1. Technical Support: Beginning with Substantial Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
a. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Plug Connectors
1. Pin Type: USITT S3, two-pole, three-wire, 20-A.
2. Twist-Locking Type: NEMA WD 6, two-pole, three-wire, 20-A.

B. Lighting Fixtures And Accessories
1. General:
   a. Comply with UL 1573 and listed and labeled by an NRTL.
   b. Fixtures: Equipped with pigtail, yoke with pipe clamp, safety cable for batten mounting, and filter holder.
   c. Metal Parts: Free of burrs, sharp corners, and edges.
   d. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
   e. Fixture Doors and Their Internal Access: Smooth operating, free of light leakage under operating conditions, and arranged to permit relamping without use of tools. Doors, lenses, diffusers, and other pieces arranged to prevent accidental falling during relamping and when secured in operating position.
   f. Pigtail: Factory wired, 36-inch- (900-mm-) long, three-wire cord and plug connector assembly with cord encased in woven fiberglass or silicone tubing.
   g. Lamp Sockets: Relampable without disturbing alignment or focus adjustment.
   h. Fixture Ventilation Openings: Baffled against light leaks.
   i. Fixture Operating Controls and Handles: Thermally insulated.
   j. Lenses: Borosilicate glass in silicone mountings.
   k. Framing Shutters: Stainless steel, four way; with each blade in a separate plane under adjustable tension mounting. Blades adjust plus or minus 30 degrees of rotation in gate, for 120-degree-minimum total angular rotation between adjacent blades.
   l. Color Filter Frame Holder: Attached to front of fixture.
   m. Fixture Yoke: Rigid metal, arranged for vertical aiming of unit and equipped with T-bolt or hand screw to lock alignment.
2. Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in a fixed relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
   a. Tag: ES-1:
      1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
      2) Pattern Holders: Three for each fixture, with framing shutters.
      3) Color Frame: Black, metal.
      4) Minimum Cosine Illumination Performance Ratings When Operated with ANSI C78 Series, FEL Lamp:
         a) 171,000 beam candlepower at 20-degree field angle.
         b) 48,000 beam candlepower at 40-degree field angle.
3. Zoom Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in an adjustable relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.
   a. Tag: ZES-1:
      1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
      2) Pattern Holders: Three for each fixture, with framing shutters.
      3) Operator adjustable from 25- to 50-degree field angle.
      4) Field-angle adjustment scale label on instrument housing for field reference.
      5) Minimum Cosine Illumination Performance Rating When Operated with ANSI C78 Series, FEL Lamp: 82,000 beam candlepower at 35-degree field angle.
4. Fresnel Lens Spotlights:
   a. Die-cast extruded-aluminum housing, with hinged front for relamping.
   b. Tag: FLS-1.
      1) Lamp: 1000 W Q1000T7/4CL, ANSI EGT.
      2) Lens: 6 inches (152 mm).
      3) Illumination Performance Rating When Operated with ANSI C78 Series, EGT Lamp:
         a) 175,000 beam candlepower at 12.5-degree field angle in spot focus.
         b) 12,000 beam candlepower at 74.6-degree field angle in flood focus.
      4) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
5. Follow Spotlights:

a. Tag: FS-1:
   1) Lamp: Metal halide, G22 medium bi-post, CRI: 90, color: 6000 K, life: 750 hours, HMI 575 W/GS 95 V.
   2) Adjustable lenses in metal housing.
   3) Lamp: Quartz-projector type, <**Insert wattage**> W, for <**Insert voltage**> V supply.
   4) Adjustable, underslung base stand mounted on 3-inch (75-mm), locking-type, rubber-tired, ball-bearing casters.
   5) Adjustable lamp holder and socket assembly with precision tuning adjustment; relampable without tools.
   6) Three-leaf, full-range mechanical dimmer.
   7) Adjustable iris and framing shutters.
   8) Automatic color boom.
   9) Removable power cable, 25 feet (8 m) long.
   10) Iris Open, Spot-Focus Performance: 800,000, **as directed**, beam candlepower at 7.2, **as directed**,-degree field angle.
   11) Iris Open, Flood-Focus Performance: 330,000, **as directed**, beam candlepower at 12.2, **as directed**,-degree field angle.

6. PAR Lamp Holders:
   a. Tag: PLH-1:
      1) Lamp: 300 W PAR 38.
      2) Housing: Steel or aluminum, flat black color, **as directed**, with porcelain-plated shell socket.
      3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
   b. Tag: <**Insert drawing designation**>.
      1) Lamp: 575 W tungsten halogen, 90 GLA 575 W, 230 V, color: 3200 K, ANSI GKV.
      2) Housing: Steel or aluminum, with porcelain-plated shell socket and color frame, **as directed**.
      3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
      4) With Lens Holder and Replaceable Lenses:
         a) <Insert drawing designation>: Very narrow spot.
         b) <Insert drawing designation>: Narrow spot.
         c) <Insert drawing designation>: Medium flood.
         d) <Insert drawing designation>: Wide flood.
         e) <Insert drawing designation>: Very wide.
      5) Motorized **OR** Manual, **as directed**, color wheel.

7. Borderlight Units: Compartmented, three-circuit striplight with nine 150-W, PAR 38/SP **OR** 150-W, PAR 38/FL **OR** 250-W, PAR 38/SP **OR** 150-W, R40/FL, **as directed**, lamps in porcelain sockets and steel sheet housing, 90 inches (2286 mm) long. Compartments shall be in line and wired on two **OR** three **OR** four, **as directed**, alternate circuits, each producing a different color.
   a. Front Door: Spring loaded; designed to hold either filter frames or color roundels.
   b. Color Roundels: One for each lamp; alternating red, blue, and clear, **as directed**.
      1) Additional Roundels: <**Insert number**> amber and <**Insert number**> green.
   c. Hanger: Adjustable, steel-strap type equipped at each end with pipe clamp and safety cable for suspension from a batten.

8. Cyclorama Lights: Suitable for lighting cycloramas from above.
   a. Tag: CL-1:
      1) Lamp: 1000 W Q1000T3/1CL, ANSI FFT.
      2) Housing: Aluminum or steel, **as directed**, flat black color, **as directed**, with color frame, **as directed**.

9. Black Lights: Portable, producing a wash of UV light for special effects.
   a. Tag: BL-1:
      1) Lamp: 250 W blacklight flood, H37KB-250, with integral filter to eliminate far-UV effect while maximizing the near-UV effect.
      2) Housing: Steel or aluminum, **as directed**, flat black color, **as directed**, with carry handle.
      3) C-clamp for using on light pipe.

10. Moving Lights:
    a. Tag: ML-1:
        1) General: 700-W, 120-V, metal halide, motorized remote-controlled lighting instrument; NRTL listed.
        2) Lamp: Short-arc metal halide, 14,500 lumens; color temperature of 5600 K, CRI of 80.
        3) Color System: Three-filter CYM (cyan, yellow, magenta) cross-fading mechanism, and 11 standard colors on a fixed wheel.
        4) Optics: Zoom optics with continuously variable field angle from 18.5 to 42 degrees, programmable over a timed range of 2 seconds to 20 minutes; with a mechanical iris for beam-size control. Variable beam focus to soften the edges of gobos and light beams. Zoom combined with iris can project a beam with a field angle of 8 degrees.
        5) Dimming: Coated glass dimmer wheel, with controls to provide smooth timed fades.
        6) Strobe for strobe lighting effects.
        7) Gobo: One rotating wheel with five rotatable wheel positions and one open position. One fixed gobo wheel with 11 pattern positions and one open position.
        8) Beam Orientation Control: Smooth pan and tilt using a three-phase stepper motor system. Pan, 540 degrees; tilt, 270 degrees at 0.3-degree repeatability on either axis.
        9) Control: ANSI E1.11 (USITT DMX512-A) protocol using five pin connectors.

C. Distribution Components
1. Connector Strip: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly.
    a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
    b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
    c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
    OR
    Receptacles: Flush mounted in wireway cover.
    d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
    e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
    f. Mounting Hardware: Furnished with each unit; permits surface, single-pipe-bracket, or double-pipe-bracket mounting.
    g. Finish: Semigloss or matte black.
2. Plug-in Boxes: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly, 24 inches (600 mm) long unless otherwise indicated; with the following features:
    a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
    b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
    c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.
    OR
    Receptacles: Flush mounted in wireway cover.
    d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
    e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
    f. Surface or Grid Mounting: With accessories for surface mounting or with pipe-mounting accessory bracket.
    g. Recessed Mounting: With flanged cover suitable for recessed mounting in wall.
    h. Finish: Semigloss or matte black.
3. Gridiron Junction Boxes: Listed and labeled by an NRTL; factory wired with terminal strips and concentric knockouts on all sides.

a. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable, and brackets for surface or pipe mounting.
c. Finish: Semigloss or matte black.

4. Floor Pockets: Listed and labeled by an NRTL; flush-mounted, receptacle outlet assembly.
   a. Box: 0.0598-inch (1.5-mm) steel sheet, 10 inches (250 mm) deep.
   b. Cover Plate: Steel, cast iron, or cast aluminum with nonskid safety tread surface and self-closing, hinged door with cable notches.
   c. Barrier for allowing installation of low-voltage control receptacle for console input or handheld remotes.

D. Wire And Cable
1. Building Wire in Raceways: Comply with requirements specified in Division 16 Section "Conductors And Cables".
2. Portable Power Cable: Listed and labeled by an NRTL; flexible stage and lighting power cable; Type SC, SCE, or SCT; 600 V; multiconductor; 60 deg C temperature rating.
3. Ethernet Cabling: Comply with requirements specified in Division 16 Section "Control-voltage Electrical Power Cables".
   a. For 10/100BaseT, comply with provisions for UTP cable and hardware.
   b. For 10Base-FL, comply with provisions for 50/125 **OR** 62.5/125, **as directed**,-micrometer, multimode, optical-fiber cable and hardware.
4. ANSI E1.11 (USITT DMX512-A) Control Cabling: Comply with requirements specified in Division 16 Section "Control-voltage Electrical Power Cables".
   a. Standard Cable: NFPA 70, Type CM **OR** Type CMG, **as directed**.
      1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
      2) PE insulation.
      3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
      4) Outer Shield: 90 percent coverage, tinned-copper braid.
      5) Outer Shield Drain Wire: Stranded, tinned copper.
      6) PVC jacket.
      7) Flame Resistance: Comply with UL 1581.
   b. Plenum-Rated Cable: NFPA 70, Type CMP.
      1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
      2) Insulation: Foam fluoridated ethylene propylene.
      3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
      4) Outer Shield: 90 percent coverage, tinned-copper braid.
      5) Outer Shield Drain Wire: Stranded, tinned copper.
      6) Low-smoke PVC jacket.
      7) Flame Resistance: Comply with NFPA 262.
5. Low-Voltage Control Cabling:
   a. Control-Cable Conductors:
      1) Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway; complying with UL 83.
         OR
         Class 1 Control Circuits: Stranded copper, Type THHN, in raceway; complying with UL 44.
      2) Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 83.
         OR

Class 2 Control Circuits: Stranded copper, Type THHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 44.

3) Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF; complying with UL 83.

b. Paired Cable: NFPA 70, Type CMG.
   1) One pair, twisted, No. 16 AWG, stranded, tinned-copper conductors.
   2) PVC insulation.
   3) Unshielded.
   4) PVC jacket.
   5) Flame Resistance: Comply with UL 1581.

c. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   1) One pair, twisted, No. 16 AWG, stranded (19x29), tinned-copper conductors.
   2) PVC insulation.
   3) Unshielded.
   4) PVC jacket.
   5) Flame Resistance: Comply with NFPA 262.

d. Paired Cable: NFPA 70, Type CMG.
   1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
   2) PVC insulation.
   3) Unshielded.
   4) PVC jacket.
   5) Flame Resistance: Comply with UL 1581.

e. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
   2) Fluorinated ethylene propylene insulation.
   3) Unshielded.
   4) Plastic jacket.
   5) Flame Resistance: Comply with NFPA 262.

E. Lighting Control System

1. Description: Microprocessor-based modular system consisting of dimmer and control modules operated from remote-control stations and a control console.
   a. Comply with UL 508.
   b. Comply with USITT AMX192 **OR** ANSI E1.11 (USITT DMX512-A), **as directed**, for data transmission.

2. Dimmer Racks: Listed and labeled by an NRTL; dead-front, front-access, wall-mounted **OR** freestanding, **as directed**, rack for mounting modular dimmers; formed-steel or extruded-aluminum structural members; completely enclosed with steel or aluminum panels. Painted with manufacturer's standard corrosion-resistant primer and finish coats, and having the following features:
   a. Primary Circuit Breaker: Fault-current withstand rating of the rack; not less than 10,000 **OR** 50,000, **as directed**, A, symmetrical.
   b. Hinged, locking front door, with openings to allow air intake across the face of all dimmer modules.
   c. Individual rack sections shall not exceed 84 inches high by 25 inches deep by 30 inches wide (2134 mm high by 635 mm deep by 762 mm wide). Multisection racks shall be interconnected with busbars.
   d. For each module position, provide support rails and control-pin configurations, constructed for precise alignment of dimmer modules into power and signal connector sockets.
   e. Forced-air cooling of each rack for maintaining operating temperature at each dimmer, assuming full load, in ambient temperature not to exceed 40 deg C. Exhaust rates shall be variable, using temperature sensors and fan-speed control electronics. Individual control of multiple fans is acceptable in lieu of fan-speed control. Fan(s) shall start and stop automatically. Fan noise at full load shall be less than 3.1 sones.

f. Each rack shall have an automatic air-temperature sensor to shut off all dimmers in the rack should the internal temperature rise above maximum safe operating limits. In an overheat condition, the fan shall continue operating. When a safe operating temperature is restored, the system shall automatically reset to allow normal user control.

g. Fabricate and test dimmer racks to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

3. Dimmers: Modular solid-state units that operate smoothly over their operating ranges without audible lamp noise or radio-frequency interference at any setting. Modules shall be dead-front, draw-out type with floating line, load, and control sockets for smooth insertion and withdrawal; with load-side thermal-magnetic circuit breaker, speed-controlled cooling fan, and overtemperature sensor.

a. Non-Dim Units: On-off relay control only. Capable of serving inductive loads such as motors or high-intensity-discharge fixtures.

b. Surge Protection: Modules shall withstand power-line surges of 6000 V/3000 A according to IEEE C62.41.1 and IEEE C62.41.2.

c. Filter each dimmed circuit to provide a minimum 350-mic.sec., current-rise time at a 90-degree conduction angle at 50 percent of rated dimmer capacity. At any load within rating, rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load current waveform.

4. Control System: Microprocessor-based control system, ANSI E1.11 (USITT DMX512-A) protocol, with a nonvolatile system memory to adjust dimmer channel settings for different scenes, to patch dimmers to channels, and to manually or automatically change dimmer settings from one preset scene to another.

a. Control shall support Ethernet-based LAN at every control device.

b. Provide means to create and monitor show data on a PC using software by console manufacturer. Software shall be capable of the following:

1) Creating show and providing for use of USITT show files.

2) Playing back show in a console-simulation mode.

3) Accessing all remote-control stations associated with the console and control system.

4) Providing standard Ethernet connection between the console control system and the PC.

c. Display the following system status information on a color, 17-inch (430-mm) LCD monitor associated with the control console:

1) Current channel intensities.

2) Cue information.

3) Monitor.

d. Moving Lights: Include a standard control library, a program patch specific to fixture(s) provided, and selective programming with ANSI E1-11 (USITT DMX512-A) addressing of fade, focus points, beam, image, color, <**Insert attributes**> and position.

5. Control Console: Tabletop unit with manual and computer-based programming controls, memory units, indicating devices, and the following features:

a. Servicing access through hinged top panel.

b. Grand-master level control.

c. Blackout switch.

d. 12 submaster level controls with overlapping pile-on performance.

OR

24 submaster level controls with overlapping pile-on performance.

e. Bump buttons for momentary control of channels or submasters, one for each submaster level control.

f. Two cross-fade controls for split dipless fade between scenes, each with its own fade progress indicator.

g. One set of scene level controls for each scene when used in two-scene preset mode. Second set of scene level controls to allow setting levels into memory for expanded single scenes when used in multiple single-channel scene mode. Each set shall have same quantity of scene level controls as is used for submaster level controls.

h. Multibutton keypad for programming in multiscene memory mode.
i. Fade time control for assigning fade time to cues, with individual cue adjustment from one second to five minutes, minimum.
j. Light-emitting diode **OR** LCD **OR** Computer monitor cathode-ray tube, **as directed**, with associated display controls, for displaying operating menus and memory readout.
k. Controls for setting levels into memory.
l. Cord and connector for connecting console to outlets for console power and control.

6. System Operation: Selectable between multichannel two-scene preset and four-channel single-scene memory. Console features include electronic patching of control signals for up to 512 dimmers and off-line data storage using internal, 3-1/2-inch (90-mm) disk-drive unit. Operational capability includes the following:
   a. Live and blind programming.
   b. Special effects programmability for automatic operation of lights in pulsating, sequential dimming and brightening, and other special operating modes. Special effects menu displays operator guidance for programming and individual step levels.
   c. Signal from fire-alarm control panel that automatically brings selected circuits to fully on or fully bright condition, overriding normal dimming and on-off controls.
   d. Inserting cues between designated cues without renumbering.
   e. Out-of-sequence playback of cues.
   f. Controlling houselights and stage lights from console by assigning their dimmers or non-dim on-off controls to a channel.
   g. Retaining programmed cues in memory for minimum of one year after power outage.
   h. Automatic sequential execution of programmed cues.
   i. Printing cues using parallel or serial printer port, cable, and printer. Cable and printer are not included with this system.
7. PC: Standard, unmodified, with accessories and peripherals that are configured to install and run control-console manufacturer's written requirements, but not less than the following:
   a. CPU operating speed shall be at least 1.6 GHz.
   b. Memory: 1024 MB.
   c. Serial Ports: Provide two for general use.
   d. Parallel Port: Enhanced.
   e. LAN Adapter: 10/100/1000 Mbps, internal network interface card.
   f. Three USB 2.0 ports.
   g. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
   h. Color Monitor: Not less than 17 inches (430 mm), with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. Video card shall support at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum refresh rate of 70 Hz.
   i. Keyboard: With a minimum of 64 characters; standard ASCII character set based on ANSI INCITS 154 (formerly ANSI X3.154).
   j. Mouse: Standard, compatible with installed software.
   k. Disk storage shall include the following, each with appropriate controller:
      1) Minimum 60 GB hard disk, 5400 rpm.
      2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
      3) <**Insert disk drives**>.
   l. CD-ROM Drive: 24x/10x/24x CD-RW/8x DVD combination.
8. Console Power and Control Outlets: Multiple receptacles matched to connector on console connector cord.
9. House Lighting Control Station: Architectural-type, multichannel, remote-dimmer-control station with the following features:
   a. System controls designated houselights, stage lights, and other lights.
   b. Stage lighting controls compatible with dimming and control system.
   c. Flush mounting.
   d. Brushed-aluminum wall plate.

e. Five **OR** Six, **as directed**, channels, each with slider potentiometer control.
f. Master-slider potentiometer that controls lights on all channels proportionally from completely dimmed to degree of brightness that corresponds to individual slider positions.
g. Fully on switch that turns all channels on at full brightness regardless of slider position.
h. Take-control/off switch that places station in control of channels and sets lighting to levels dictated by channel and master-slider controls.
i. Legend on face of wall plate that identifies items as "House Lighting Control Station" and identifies functions of each slider and switch position, with slider positions individually graduated from zero to 10.
j. Illuminated push buttons for activating preset scenes of house lighting and labeled "Entry" **OR** "Panic" **OR** "Entry" and "Panic," **as directed**.
k. Flush wall mounted unless otherwise indicated.

10. Entry Station: Push button activates or deactivates indicating light and presets scene of house lighting control system.
    a. Light-emitting-diode indicating light illuminates when preset command is executed.
    b. Labeled "Entry."
    c. Flush wall mounted unless otherwise indicated.
11. Key-Entry Station: Key-operated switch controls station to activate or deactivate indicating light and presets scene of lighting control system.
    a. Light-emitting-diode indicating light illuminates when preset command is executed.
    b. Labeled "Entry."
    c. Flush wall mounted unless otherwise indicated.
12. Emergency Lighting Control Station: Key-operated, **as directed**, push button activates indicating light and brings selected dimmers to fully bright condition, i.e., the "Panic" preset. Operating push button a second time returns dimmers to previous setting.
    a. Emergency mode indicating light.
    b. Labeled "Emergency Lights."
    c. Flush wall mounted unless otherwise indicated.

F. Rigging Components
1. Pipe Clamps: Malleable iron, suitable for clamping fixtures or items to pipe from 3/4 to 2 inches (20 to 51 mm) in OD. Arranged for horizontal rotation of yoke for aiming; equipped with T-bolt to lock alignment.
2. Safety Cables: Heavy-duty, flexible steel; 30-inch (762-mm) nominal length, with spring clip at one end and steel ring at the other end.
3. Cable Grips: Stainless **OR** Galvanized, **as directed**, steel; basket-weave type for supporting stage cables.

1.3 EXECUTION

A. Installation
1. Set permanently mounted items level, plumb, and square with ceilings and walls.
2. Indicated mounting heights are to bottom of unit for suspended items and to center of unit for wall-mounted items.
3. Mount and connect fixtures, and install and connect distribution devices.
    a. If arrangement is not indicated, install so each fixture, dimmer, house lighting circuit, control channel, and outlet circuit can be operated, and complete system demonstrated, in all operating modes.
    b. Install safety cables secured to stage rigging or gridiron for all pipe-mounted electrical fixtures and equipment.
4. Dimmer Rack Mounting: Install and anchor dimmer racks level on 4-inch- (100-mm-) high concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
    a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.

b. For dimmer racks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
d. Install anchor bolts to elevations required for proper attachment to dimmer racks.

5. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

B. Wiring

1. Power Wiring:
   a. Install wiring as specified in Division 16 Section "Conductors And Cables" for hardwired connections. Install wiring in raceways except cable and plug connections.
   b. Install power wiring with a separate neutral for each output circuit from main dimmer and for each house and stage lighting circuit.
2. Signaling, Remote-Control, and Power-Limited Circuits:
   a. Comply with requirements specified in Division 16 Section "Control-voltage Electrical Power Cables" for installation of wiring. Install wiring in raceways except cable and plug connections.
   b. Comply with the following unless otherwise indicated:
      1) Size conductors according to lighting control device manufacturer's written instructions.
      2) Select cable insulation, shielding, drain wire, and jacket complying with lighting control device manufacturer's written instructions.
      3) Install circuits to eliminate radio-frequency interference and electromagnetic interference.
   c. Remote-control circuits associated with emergency lighting control shall be installed complying with Class 1 Circuit standards in NFPA 70.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes and in terminal cabinets and equipment enclosures.
5. Remove wall plates and protect devices and assemblies during painting.
6. Support lighting fixtures, distribution components, and accessories as specified in Division 16 Section "Hangers And Supports For Electrical Systems". Equip all pipe-mounted equipment with safety cables that are secured to supporting pipe.
7. Ground equipment according to Division 16 Section "Grounding And Bonding".

C. Identification

1. Identify components, power, and control wiring according to Division 16 Section "Electrical Identification".
2. Label each fixture, lighting outlet, distribution device, and dimmer module with unique designation. Labels on elevated components shall be readable from the floor.

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
   a. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
   b. Visual and Mechanical Tests and Inspections:
      1) Inspect each fixture, outlet, module, control, and device for defects, finish failure, corrosion, physical damage, labeling by an NRTL, and nameplate.
      2) Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's written instructions.
      3) Check tightness of electrical connections with torque wrench.
      4) Verify proper protective device settings, fuse types, and ratings.
      5) Record results of tests and inspections.

c. Electrical Tests: Perform tests according to manufacturer's written instructions.
   1) Continuity tests of circuits.
   2) Operational Tests: Connect each outlet to a fixture and a dimmer output circuit so each dimmer module, dimmer control and output circuit, outlet, and fixture in a typical operating mode will be sequentially tested. Set and operate controls to demonstrate fixtures, outlets, dimmers, and controls in a sequence that cues and reproduces actual operating functions for a typical system of the size and scope installed. Include operation and control of houselights and stage lights from each control location and station including optional plug-in, control-console outlet locations. Record fixture and outlet assignments, control settings, operations, cues, and observations of performance.

d. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and individual.

3. Stage lighting will be considered defective if it does not pass tests and inspections.

4. Prepare test and inspection reports.

   a. Prepare a schedule of lighting outlets by number; indicate circuits, dimmers, connected fixtures, and control-channel assignments. Prepare a schedule of control settings and circuit assignments for house control channels. Prepare written reports of tests and observations. Report defective materials, workmanship, and unsatisfactory test results. Include records of repairs and adjustments made.

E. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 16555

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Task	Specification	Specification Description
16570	01352	No Specification Required
16570	16330a	Overhead Electrical Distribution
16570	16521	Exterior Lighting

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SECTION 16622 - NURSE CALL

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for nurse call. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes visual/tone and audiovisual/voice nurse-call system.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   a. Detail equipment cabinets and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   b. Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment. Include cable type for each interconnection.
   c. Station Installation Details: For built-in equipment, dimensioned and to scale.
3. Qualification Data: For qualified Installer.
4. Field quality-control reports.
5. Operation and Maintenance Data: For nurse-call equipment to include in emergency, operation, and maintenance manuals.
6. Warranty: Sample of special warranty.

D. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Compatibility: System shall be capable of integration with any brand of phone system (wired or wireless), staff locating system, CCTV, and fire-alarm system.
3. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty for batteries applies to materials only, on a prorated basis for specified period.
   a. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
      1) Nickel-Cadmium Batteries, Lithium Batteries, and Wet-Cell Batteries:
         a) Full Warranty: Five years.
         b) Pro Rata: 15 years.

1.2 PRODUCTS

A. Nurse-Call System General Requirements
1. Station Zones: Able to program 256 station zones for each master station in the network with eight priority levels and addressable visual and audible annunciation of audible devices such as smoke detectors and door contacts.
2. System shall provide integrated and centralized "Code Blue" and "Staff Emergency" calls.

3. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 25 percent above those indicated without adding internal or external components or main trunk cable conductors.
4. Existing System Compatibility: Functionally and electrically compatible with existing system so components and wiring operate as an extension or upgrade of the existing system and existing or upgraded functional performance of the existing system applies to the entire final system. Colors, tones, types, and durations of signal manifestation shall be common among new and existing systems.
5. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.
6. Equipment: Microprocessor, electronic, modular.
7. Master Nurse-Call Station: Programmed via a PC.
8. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.
9. Telephone Interface: Permit use of wired and wireless telephones to execute nurse-call master station functions.
10. Third-Party Pager Interface: Programmable to send tone, numeric, and alphanumeric message to pocket pagers or personal digital assistants and to use industry standard-protocol, RS-485 interface.

B. Visual/Tone Nurse-Call System
1. Operational Requirements:
   a. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and other system display devices and displays message on master and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the respective annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.
   b. Pull-Cord-Call Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station, priority as programmed, and bed identification.
   c. Emergency-Call Station Call: Produces the same responses as pull-cord-call station calls except rapidly flashing red emergency digital display and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be extinguished and the system reset only at the calling station. Displays message on pocket pagers, sounds programmed tone on phones, and displays message on display equipped phones.
   d. System Reset: Operating reset button at the originating station cancels signals associated with the call. Illuminates a green digital display on the patient station and log presence on the master station.
   e. Cord-Set Removal: Initiates a patient station call when the cord set is removed from the jack in the patient station faceplate. Displays location and "cord removed" message on master station, pocket pagers, and display equipped phones. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button resets the call.
   f. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.
   g. Emergency Bath Station Call: Illuminates the digital display on the emergency bath station; rapidly flashes white dome lamp; displays location, priority, and bath on master

station; and sounds programmed tone on master station display equipped phones and pocket pagers.

h. Staff/Duty Station Operation: Operation shall be identified to patient station except the message staff shall display on all devices when the staff call button is activated.

i. Privacy Key Activation: When privacy key is activated on patient station, the system shall disconnect the patient station microphone and slowly flash yellow privacy digital display on the patient station. Displays "privacy" on master station when selecting this room/bed.

2. Central Annunciator:
   a. Lamp type.
   b. Lamp Legends: Machine lettered and legible from a distance of at least 48 inches (1200 mm) when a call is present. Legend shall identify initiating station and priority of call.
   c. Power-on Indicator: Digital, or push-to-test switch.
   d. Audible Signal: Electronic tone.
3. Central Equipment Cabinet:
   a. Lockable metal.
   b. Houses power supplies, controls, terminal strips, and other components.
   c. Power-on indicator lamp.
   d. Battery Backup Unit: Sealed nickel-cadmium, wet-cell battery supplies power through an automatic switch when normal power fails, for a period of not less than six minutes at rated output. System shall lose no unanswered calls or calls in progress during the transfer operation.
      1) Automatic retransfer to normal power, after a 15-minute time delay.
      2) Two-rate battery charger with an automatic trickle rate and a recharge rate.
4. Single-Patient Station: Call-placed lamp, reset push button, and polarized receptacle matching cord-set plug; mounted in a single faceplate.
5. Dual-Patient Station: Single call-placed lamp, single reset push button, and two polarized receptacles matching cord-set plug; mounted in a single faceplate.
6. Ambulatory-Patient Station: Call push-button switch, call-placed lamp, and reset push button; mounted in a single faceplate.
7. Staff/Duty Stations: A minimum of two call lamps, one for routine calls and one for emergency calls; and an audible tone signal device.

C. Audiovisual/Voice Nurse-Call System
1. Operational Requirements:
   a. Station Selection from Master Station: Capable of selectively communicating with other stations or groups of stations on its system by touch screen, mouse click, or manual switch; and capable of programming up to 256 stations for each master station in the network.
   b. Master Station Privacy: Capable of conversing with individual stations in complete privacy.
   c. Called Station:
      1) Capable of hands-free and two-way conversation.
      2) Pressing "talk/listen" key shall cause the annunciation tone to cease.
      3) Pressing "cancel" key terminates normal calls and conversations.
      4) Terminating of high-priority level 1 **OR** 2 **OR** 3 **OR** 4, **as directed**, shall not be allowed except at calling station location and shall send "remind" message if the call is not acknowledged at point of origin in programmed time frame.
   d. Annunciation:
      1) At the master station, a programmable tone announces an incoming call; an annunciator light or digital display identifies the calling station and indicates the priority of the call.
      2) Call type indications include alarm assist, bath, bed, code, communication fault, cord out, door, emergency, and fire.
      3) Memory lamps or lighted displays identify stations selected for outgoing calls.
   e. System Reset at Master Station: A normal, incoming call can be canceled, associated lights and audible tones extinguished, and the system reset when the station switch is returned to the normal position.

f. Patient Station Calls:
   1) Lights the call-placed lamp at patient station, zone, and corridor dome lights.
   2) Sounds a tone and lights the call lights at staff/duty stations and actuates annunciation at the master station.
   3) When the calling station is selected at the master station, the patient can converse with the master station without moving and without raising or directing the voice.
   4) During voice communications, entertainment audio at the calling station is automatically muted.

g. Pull-Cord-Call Station Calls and Emergency-Call Station Calls:
   1) Lights call-placed lamp and corridor dome light and flashes zone light.
   2) Master station tone pulses and annunciator light for that room flashes.
   3) When master station acknowledges the call by touch screen or switch, the tone stops but lights continue to flash until the call is canceled at the initiating point.

h. Code Blue and Staff/Duty Station Calls:
   1) Lights the call-placed lamp at the station and actuates annunciation at the master station.
   2) When the called station is selected at the master station, the caller and the master station operator can converse.
   3) Code Blue: Unique sound and light pattern indicating the highest priority emergency.
   4) Staff Station: Unique sound and light pattern indicating an emergency.
   5) Duty Station: Sound and light pattern indicating a call to the nurse station.

i. Handset Operation: Lifting the handset on master station disconnects speaker/microphone and transfers conversation to the handset.

j. Station Privacy: No patient or staff/duty station can be remotely monitored without lighting a warning lamp at the monitored station.

k. Patient Station Cord-Set Removal:
   1) A patient station call is initiated as described above when a patient station cord-set plug is removed from the jack in the station faceplate.
   2) Tone stops but lights continue to flash until the call is canceled at the initiating point or the plug is reinserted or replaced with a dummy plug when the master station call button for the station is pressed.

l. Patient Control Unit:
   1) Controls entertainment volume and channel selection.
   2) Speaker is used for both nurse communication and entertainment sound.
   3) Entertainment sound is automatically muted when station is communicating with master station.
   4) Nurse button on the unit initiates a patient station call.

m. Selective Paging: Master station is capable of initiating a message to selected groups of stations or speakers simultaneously by using station group switches.

n. Staff Reminder:
   1) Master station can initiate a staff reminder that a patient requires direct staff response by operating a reminder control while in contact with the patient station.
   2) This reminder will light a distinctive-color lamp in the corridor dome light at the patient's room and in the appropriate zone lights.
   3) Reminder calls are canceled by operating a staff reminder cancel switch in the patient's room.

o. Call Priority Indication:
   1) Capable of eight call priority levels in addition to normal.
   2) Call priority switch near each patient station, or integral with the master station, shall control priority status of the call transmitted by individual stations.
   3) Switch selects one of the following status levels:
      a) Normal: No change to the normal call initiation and canceling sequence.

b) Emergency: Call initiation produces signals and indications identical to those of emergency-call stations. Indicator lamps are extinguished and the system is reset only at the originating station.

c) Priority: System response is the same for emergency status except voice communication between the master station and the calling station is locked in from the time of call initiation until the system is reset at the originating station.

p. Additional Call:

1) Waiting display window on the master station similar to current call window displays incoming calls.
2) Master station shall have a call-overflow indicator when incoming calls exceed <**Insert number**> calls.
3) System shall store unlimited number of incoming calls.
4) System shall be capable of automatically answering incoming calls in order of priority.

q. Calling Intercom Stations:

1) Master station shall be capable of calling any intercom station using the handset or the hands-free speaker/microphone.
2) Receipt of a call at the intercom station shall be preceded by an optional pre-announce tone.
3) If there is a call in process, system shall place the active call on automatic hold while the new call is placed, then reestablish the previous call when the new call has ended.

r. Privacy Override:

1) Temporarily deactivates the "Privacy" mode of a called station by calling the station and instructing the called party to press the call-cord button.
2) On completion of the conversation, the called station shall automatically return to the "Privacy" mode.
3) When in "Privacy" mode, a called station shall be capable of hearing the master station; however, the master station shall not be capable of hearing the called station; a privacy message shall be indicated on the master station display.

s. Master-Station-to-Master-Station Calls:

1) Master stations shall be capable of calling other master stations using the handset.
2) Calls from master stations shall be answered using the handset only.
3) Busy master stations shall be indicated by a master station intercom busy tone.

t. Voice Paging:

1) Capable of voice paging to all stations using a single "All Call" key. The page shall be preceded by an optional pre-announce tone, **as directed**.
2) Capable of voice paging to eight user-defined groups of stations by selecting the group and then the "All Call" key. The page shall be proceeded by a pre-announce tone, **as directed**.
3) Capable of voice paging to all staff/duty stations and all patient stations where staff has registered presence using a single "Public Address (PA)/Staff" key. The page shall be proceeded by a pre-announce tone, **as directed**.
4) Capable of voice paging through a third-party PA system.
5) Capable of including or excluding any station from the voice paging function(s).
6) Automatically places an active station call on hold during any page and reestablishes the connection at the end of the page.
7) Automatically cancels a page if the talk mode is inactive for more than 15 seconds.

u. Station Monitor:

1) An audio monitor feature shall allow a user to sequentially or simultaneously listen to one or all stations that are included in the user-created list.
2) Master station display shall indicate which station is being monitored when in sequential mode.
3) The dwell time each station is monitored shall be user programmable.
4) The user shall be able to stop the monitoring sequence by activating a "pause" key.

5) The user shall be able to manually sequence through stations using a "next" key.

v. Night Service:
1) Functions shall be adaptable for nighttime staffing levels, patient traffic, and day/night operations.
2) Staff Follow:
a) Capable of locating roving staff; forwarding visual and audible annunciation of incoming calls to station(s) where personnel have registered presence.
b) Master station shall display locations where staff have registered presence.
c) Incorporates a programmable timer that automatically cancels a forgotten staff presence registration.
3) Tones:
a) Deactivates audio signals from a duty station and mini-master display telephones.
b) Capable of changing the tone volume at the master and duty stations.
c) Satellite function shall permit the user to deactivate audio signals from duty stations and other remote annunciator devices.
4) Transfer:
a) Permits one nurse station to take control of all or individually selected bed call cords from another nurse station. It shall be possible to view transfer status of a nurse station.
b) Includes a minimum of three transfer modes to allow one nurse station to take control or share calls and operations from another nurse station.
i. Parallel Transfer Mode: Permits both nurse stations to share all calls and operations.
ii. Supervised Transfer Mode: Permits the transferred nurse station to share all calls and operations with the controlling nurse station; however, the controlling nurse station calls are not shared with the transferring station.
iii. Capture Transfer Mode: Transfers all calls and operations from the transferred nurse station to the controlling nurse station.
iv. Transferred station shall have no control over calls, and its display shall indicate calls have been transferred to another station.
c) Includes two "patient swing" modes to allow one nurse station to take control or share calls from one or many calls from another nurse station.
i. Supervised Transfer Mode: Permits the transferred calls to be shared with the controlling nurse station.
ii. Capture Transfer Mode: Transfers all calls from the call cord from the transferred nurse station to the controlling nurse station.
iii. Transferred station has no control over those transferred calls.

w. Service Request:
1) Permits users to assign a service request to a substation, at programmable priority level.
2) Displays service request on the nurse station display and light the green flashing corridor lamp at the respective substation and automatically generate a service reminder request.
3) Cancels service requests only at the initiating point.
4) Recall calls shall sound and be displayed at the master station if the service request has not been cancelled at the initiating point within the programmed period of time.

x. Call Reminder Function:
1) Automatically generates a reminder call for a patient- or staff-initiated, high-priority 2 **OR** 3 **OR** 4, **as directed**, request that has had the call tones silenced, allowing time to physically attend to the request and cancel the call at the initiating point.
2) Regenerated calls shall display the same tones and visual indications and priority as the original call and shall also display a "regenerated call" message.
3) Capable of manually adding low-priority calls to the reminder list.

4) "Call Reminder" function and reminder timer shall be programmable by call priority.

y. Hide Function: Prevents a selected station from displaying calls or generating tones on the nurse station.

z. Door Control Function: Capable of being programmed to enable the user to remotely activate electric door locks.

aa. Test and Diagnostics Feature:
1) Able to automatically diagnose system faults and categorize them as warnings, communication errors, or fatal errors.
2) Warnings shall indicate possible system problems.
3) Communication errors shall indicate the inability of the master station to communicate with a substation or another nurse-call station.
4) Fatal errors shall indicate a major hardware or software failure.

bb. User-Configured System Programming - Access Code Not Required:
1) Patient call-cord priority levels.
2) Monitor list.
3) "All Call" list.
4) Master station communication parameters (volume, filtering, talk/listen, sensitivity).
5) Master and duty station call annunciation tone volume.
6) Date/time.
7) Staff-follow operating mode.
8) Transfer type.
9) Pocket pager list assignment.
10) Presence mode.

cc. User-Configured System Programming - Access Code Required:
1) Master station number.
2) Room device type.
3) Room number.
4) Bed number.
5) Bed alpha or numeric.
6) Reminder duration.
7) Staff presence registration cancel duration.
8) Display language.
9) Paging group assignment(s).
10) Zone group assignments.
11) Monitoring duration.
12) Pocket pager number.
13) Call tone assignment by priority.
14) Pretone activation.
15) Call tones minimum volume.
16) Clock mode (12 h/24 h).

2. Master Station:

a. Speaker/microphone unit with operating controls.

b. Indicator lamps with legends or by digital display designate identification and priority of calling stations and called stations.

c. Pulse rate of incoming-call lights denotes priority of calls awaiting response.

d. Station Selection Controls: Touchpad select stations for two-way voice communications.

e. Signal Tones: Programmable to announce incoming calls.

f. Pulse rate and frequency of tone identify the highest priority call awaiting response at one time.

g. Volume Control: Regulates incoming-call volume.

h. Privacy Handset with Hook Switch: Of the type that does not require push-to-talk switch attached to each station unless otherwise indicated.

i. Staff Reminder Control: Initiates flashing of corresponding corridor dome lights for patients requiring service. Permits scanning equipment to indicate which patients are currently in reminder status.

j. Call Priority Selection: Controls associated with patient-station selection switches determine the priority displayed when a call is initiated at a patient station.

3. Central Equipment Cabinet:
   a. Lockable metal.
   b. Houses amplifiers, tone generators, power supplies, controls, terminal strips, and other components.
   c. Amplifier: With fidelity and overall gain necessary to achieve the sound-transmission and reproduction characteristics specified, considering interoperability with the installed speakers/microphones and wiring.
      1) Power Output: Not less than 3 W at a total harmonic distortion not exceeding 5 percent.
      2) Hum and Noise: 60 dB below full output with normal input open.
      3) Volume Control: Concealed within the amplifier unit to control the volume of sound reproduced at all stations.
      4) Protection: Circuit to prevent damage to the amplifier in case of shorted or open circuit.
   d. Selective Paging Amplifiers: Plug-in card mounted in central equipment cabinet, rated 15 W.
   e. System Power Supply:
      1) 24-V dc for operation of the call system.
      2) Equipment Rating: Suitable for continuous operation between 32 and 120 deg F (0 and 49 deg C), from a primary line voltage between 105- to 125-V ac, 60 Hz.
      3) Output: Regulated 24-V dc with protection against overloads. Line-to-load regulation shall not exceed 2-1/2 percent with ripple and noise remaining below the 10-mV, rms level.
      4) Overload Protection: Electronic fold-back circuit set to limit the volt-ampere output to less than 100 VA during overloaded or shorted output. Restore power output automatically on removal of overload without resetting circuit breakers or replacing fuses.
   f. Power-on indicator lamp.
   g. Surge Protector Device: Comply with Division 16 Section "Transient Voltage Suppression" for auxiliary panel suppressors, with digital indicator lights for power and protection status.
   h. Battery Backup Unit: Sealed nickel-cadmium, wet-cell battery supplies power through an automatic switch when normal power fails, for a period of not less than six minutes at rated output.
      1) Automatic retransfer to normal power, after a 15-minute time delay.
      2) Two-rate battery charger with an automatic trickle rate and a recharge rate.
4. Speaker/Microphones:
   a. Type: Permanent-magnet, dynamic or ceramic, protected against dust and humidity.
   b. Sound Reproduction: Sound level of 90 dB plus or minus 3 dB at a distance of 48 inches (1220 mm) on the axis without overdriving or distorting any frequencies between 300 and 3000 Hz when installed in an enclosure or in the pillow speaker.
   c. Power Handling Capacity: Not susceptible to damage from overdriving within the range of power available from the amplifier.
   d. Impedance Matching: Coordinated and matched to the input and output circuits of the amplifier, both for single connection and for group monitoring, to provide the sound reproduction specified. Subsystems or components shall not be combined, which could cause unacceptable distortion such as feedback between pillow speakers and unmuted room speaker/microphone combinations. This protection shall extend throughout the entire range of operation (volume control) of all components.
5. Single-Patient Station: Speaker/microphone with 2-inch (50-mm) dynamic cone, a polarized receptacle to match the cord-set plug, monitor lamp, reset switch, and call-placed lamp; assembled under a single faceplate.
6. Dual-Patient Station:

a. Speaker/microphone with 2-inch (50-mm) dynamic cone, two polarized receptacles to match cord-set plugs, monitor lamp, and reset switch; assembled under a single faceplate.
b. Single call-placed lamp serves both beds.
OR
Dual call-placed lamps, one for each bed.

7. Staff/Duty Stations: Audible call-tone signal device, speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, routine-call lamp, emergency-call lamp, and call push button; assembled under a single faceplate.
8. Code Blue Station: Audible call-tone signal device, speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, Code Blue emergency-call lamp, and call push button; assembled under a single faceplate.
9. Ambulatory-Patient Station: Speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, call-placed lamp, and call push button; assembled under a single faceplate.
10. Selective Paging Speakers: 8-inch (200-mm) cone type with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet, multitap matching transformer, flush-mounted steel back-box, and white enamel-finished metal ceiling grille.
11. Call Priority Switch Station: Three-position, tamper-resistant priority selection switch. Positions designated by labeling "Normal," "Emergency," and "Priority."
12. Staff Reminder Cancel Switch Station: Momentary contact.

D. System Components
1. Emergency-Call Station: Locking-type push button, labeled "Push to Call Help"; reset trigger to release push button and cancel call; and call-placed lamp, mounted in a single faceplate.
2. Emergency-Bath Station:
   a. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "URGENT" in bold letters.
   b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
   c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
   d. Water resistant and able to withstand routine cleaning and chemical disinfectants.
   e. Uses magnetic reed switch technology for reliability and corrosion resistance.
   f. Mounts on a single-gang electrical box wire to the respective patient station or input controller.
3. Code Blue Station:
   a. Consists of a sliding, chemical-resistant, ABS blue fascia marked with the word "CODE" in bold letters.
   b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
   c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
   d. Water resistant and able to withstand routine cleaning and chemical disinfectants.
   e. Uses magnetic reed switch technology for reliability and corrosion resistance.
   f. Mounts on a single-gang electrical box wire to the respective patient station or input controller.
4. Staff, Emergency Station:
   a. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "EMERGENCY" in bold letters.
   b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
   c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
   d. Mounts on a single-gang electrical box wire to the input controller.
5. Pull-Cord-Call Station:
   a. Pull-Down Switch: Lever-locking type, labeled "Pull Down to Call Help."
   b. Reset trigger.

c. Call-placed lamp.
d. Water-resistant construction.

6. Patient Control Unit:
   a. Equipped with plug and 96-inch- (2400-mm-) long white cord.
   b. Ethylene oxide, sterilizable.
   c. Light-Control Switch: Arranged for independent on-off control of patient's up and down light.
   d. Integral Speaker: 2 inches (50 mm), with 0.35-oz. (9.9-g) magnet, rated 0.2 W.
   e. Controls: Speaker volume, TV control, and nurse call.
   f. Housing: High-impact white plastic.
   g. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
   h. Quantity: 12 units for every 10 patient beds.
7. Call-Button Cord Set:
   a. Plug and 72-inch (1800-mm) white cord; cord set shall be resistant to medical gas environment equipped with momentary-action, call-button switch.
   b. Ethylene oxide, sterilizable.
   c. Washable cord.
   d. Palladium switch contacts in high-impact white housing with cord-set strain relief.
   e. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
   f. Quantity: Three cord sets for every 10 patient beds.
8. Geriatric Call-Button Cord Set:
   a. Plug and 72-inch (1800-mm) white cord.
   b. Resistant to medical gas environment equipped with momentary-action, light-pressure switch in soft outer jacket.
   c. Ethylene oxide, sterilizable.
   d. Washable cord.
   e. Palladium switch contacts in high-impact white housing with cord-set strain relief.
   f. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
   g. Quantity: Two cord sets for every 10 patient beds.
9. Squeeze-Bulb Switch Cord Set:
   a. Plug and 72-inch (1800-mm) washable tube with white cord set.
   b. Resistant to medical gas environment; washable; equipped with neoprene squeeze-bulb activator, and plug-mounted, momentary contact switch.
   c. Ethylene oxide, sterilizable.
   d. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
   e. Quantity: Two cord sets for every 10 patient beds.
10. Breath Call Cord:
    a. Flexible PVC jacketed cable and a momentary contact air-pressure sensitive switch.
    b. Cord: 108 inches (2700 mm) long.
    c. Include an adjustable arm for clamping and suitable for use in oxygen atmospheres.
    d. Include 12 replacement straws.
11. Pillow Speakers:
    a. Eight-conductor, DIN, flexible PVC jacketed cable.
    b. Contain nurse-call button, volume control, speaker, and channel control in molded flame-retardant ABS housing.
    c. Cord: 96 inches (2400 mm) long with sheet clip.
12. Call-Button Plug:
    a. Designed to plug into patient station cord-set receptacle.
    b. Button switches call circuit.
    c. Two plugs for every 10 patient beds.
13. Dummy Plugs:
    a. Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used.
    b. Three plugs for every 10 patient beds.
14. Indicator Lamps: Digital type with rated life of 20 years unless otherwise indicated.

15. Station Faceplates:
    a. Stainless steel, a minimum of 0.0375 inch (0.95 mm) thick.
    b. Finish: Brushed.
    c. Machine-engraved labeling identifies indicator lamps and controls.

    OR

    Station Faceplates:
    a. High-impact plastic.
    b. Color: Beige.
    c. Molded or machine-engraved labeling identifies indicator lamps and controls.
16. Corridor Dome Lights and Zone Lights:
    a. Three-lamp signal lights.
    b. Lamps: Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
    c. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.
    d. Filters: Two per unit, amber and red.
17. Cable:
    a. Conductors: Jacketed single and multiple, twisted-pair copper cables.
    b. Sizes and Types: As recommended by equipment manufacturer.
    c. Cable for Use in Plenums: Listed and labeled for plenum installation.
18. Grounding Components: Comply with requirements in Division 16 Section "Grounding And Bonding".

E. Software Requirements
1. Telephone System Interface:
    a. Permits use of wired and/or wireless telephones to execute nurse-call master station.
    b. Two-way communication with patient and staff stations.
    c. Two-way communication with the master nurse station.
    d. "All Call," group call, and staff call paging.
    e. Capable of being programmed to forward calls destined for a master nurse station to any connected telephone.
    f. Telephones connected to the telephone interface shall have the same call tone ring patterns as those generated at the master nurse station.
    g. Telephones having a display shall indicate the call type, priority code, and the calling station number of incoming calls.
    h. Telephones shall be capable of initiating a service request for a particular patient station, logging calls on the master station's reminder list, and activating door lock mechanisms associated with a call station.
    i. Capable of routine setup and configuration changes using the keypads on display telephone and/or the master station.
2. Display Telephones:
    a. Digital telephones for use as mini-master nurse-call stations.
    b. Digital display shall indicate the call type, priority code, and calling station number of incoming calls.
    c. Ring patterns shall be identical to those generated at the master station.
    d. Capable of two-way communication with patient and staff stations and the master station, and other telephones interfaced with the system.
    e. Capable of placing or answering outside calls when interfaced with the facility telephone system.
    f. Capable of "All Call," group call, and staff call paging and of initiating service requests, logging calls to the reminder list, and activating optional door controls.
3. Third-Party Pocket Pager Interface:
    a. Equipped with a standalone pocket pager interface.
    b. Connects with the facility paging system and transmit alphanumeric messages to the pocket pagers as preprogrammed in the system.
4. Statistical Software:

a. Includes a data statistical software package that stores, sorts, and analyzes activities occurring on the nurse-call system network.
b. Windows based and operated on a PC that is connected to the nurse-call system network.
c. Stores events on the PC's hard disk. Accumulation of these stored events shall make up the database that is used to generate reports and statistics.
d. Events stored by the software shall include date, day of week, time, ward, priority, and room number.
e. Capable of assigning a patient name to bed number.
f. Stored events shall include, but not be limited to, calls placed, call priority, calls cancelled at the nurse station, calls cancelled at the point of origin, regenerated calls, calls answered, calls sent to pager interface, staff presence registration, staff presence cancellation, service request, service cancellation, and system and network error messages.

5. Data Analysis Software:
   a. Capable of analyzing the stored information and generating computed analysis.
   b. Analysis of the database can be conducted by specifying one, many, or all of the following parameters of the database: date, day of week, time, wards, priority, and room number.
   c. Analysis shall include, but not be limited to, total number of calls placed, average call response time (from call placed to call cancellation), total number of presence registrations, average presence time in a room, total number of service requests, average response time (from audio answer to call cancellation), and average ring time (from call placed to audio answer).
6. Statistical Software Package:
   a. Capable of displaying multiple calls/events on a PC monitor or on a RS-485 data-bus-driven digital display panel.
   b. Calls from patient or staff stations and associated devices shall be displayed by priority. Display shall be customizable as follows:
      1) Choice of color by type of call.
      2) Choice of display size (character size).
      3) Choice of priority levels, type of events, points of origin.
      4) Identification of facility.
      5) Identification of ward.
      6) Identification of patient with specific patient information.

F. Conductors And Cables
1. Audio Cables:
   a. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
   b. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
   c. Shielding: For speaker/microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
   d. Minimum Shielding Coverage on Conductors: 60 percent.
   e. Plenum Cable: Listed and labeled for plenum installation.
2. Data Cable and Hardware: Category 5e **OR** Category 6, **as directed**, UTP and UTP hardware. Comply with requirements in Division 16 Section "Communications Horizontal Cabling".
3. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in Division 16 Section "Conductors And Cables".
4. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in Division 16 Section "Conductors And Cables".

1.3 EXECUTION

A. Installation
1. Wiring Method:

a. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**.
   1) Install plenum cable in environmental air spaces, including plenum ceilings.
   2) Conceal raceway and cables except in unfinished spaces.
b. Cable Trays: Comply with requirements in Division 16 Section "Communications Horizontal Cabling".
c. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes". Flexible metal conduit shall not be used, **as directed**.
   1) Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2. Install cables without damaging conductors, shield, or jacket.
3. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.
4. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
   a. Pull cables simultaneously if more than one is being installed in same raceway.
   b. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
   c. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
5. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, or fittings.
6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
7. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide 12-inch (300-mm) minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.
8. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.
9. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.
10. Identification of Conductors and Cables: Comply with requirements in Division 16 Section "Communications Horizontal Cabling" for cable administration, cable schedule, and cable and wire identification.
11. Equipment Identification:
    a. Comply with requirements in Division 16 Section "Electrical Identification" for equipment labels and signs and labeling installation requirements.
    b. Label stations, controls, and indications using approved consistent nomenclature.

B. Existing Systems
   1. Examine existing systems for proper operation, compatibility with new equipment, and deficiencies. If discrepancies or impairments to successful connection and operation of interconnected equipment are found, report them and do not proceed with installation until directed. Schedule existing systems' examination so there is reasonable time to resolve problems without delaying construction.

C. Grounding
   1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.

2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.
3. Grounding Provisions: Comply with requirements in Division 16 Section "Grounding And Bonding".

D. Field Quality Control
1. Perform tests and inspections.
2. Tests and Inspections:
   a. Schedule tests a minimum of seven days in advance.
   b. Report: Submit a written record of test results.
   c. Operational Test: Perform an operational system test and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and "All Call" messages and pages at each nurse-call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:
      1) Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 mPa of sound pressure.
      2) Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
      3) Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.
   d. Test Procedure:
      1) Frequency Response: Determine frequency response of two transmission paths by transmitting and recording audio tones.
      2) Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings using the following procedure: Disconnect a speaker/microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
      3) Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse-call equipment amplifier, and measure the distortion in the amplifier output.
3. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.
4. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
5. Prepare test and inspection reports.

E. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal operating hours for this purpose.

F. Demonstration
1. Train Owner's maintenance personnel and caregiver staff to adjust, operate, and maintain nurse-call equipment.

END OF SECTION 16622

SECTION 16622a - PUBLIC ADDRESS AND MASS NOTIFICATION SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of public address and mass notification systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes:
a. Preamplifiers.
b. Power amplifiers.
c. Transfer to standby amplifier.
d. Microphones.
e. Volume limiter/compressors.
f. Control console.
g. Equipment cabinet.
h. Equipment rack.
i. Telephone paging adapters.
j. Tone generator.
k. Monitor panel.
l. Loudspeakers.
m. Noise-operated gain controllers.
n. Microphone and headphone outlets.
o. Battery backup power unit.
p. Conductors and cables.
q. Raceways.

C. Definitions
1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
2. VU: Volume unit.
3. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

D. Performance Requirements
1. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Supports and seismic restraints for control consoles, equipment cabinets and racks, and components shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.

a. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
b. Console layouts.
c. Control panels.
d. Rack arrangements.
e. Calculations: For sizing backup battery.
f. Wiring Diagrams: For power, signal, and control wiring.
1) Identify terminals to facilitate installation, operation, and maintenance.
2) Single-line diagram showing interconnection of components.
3) Cabling diagram showing cable routing.

3. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
a. Detail fabrication and assembly of supports and seismic restraints for control consoles, equipment cabinets and racks, and components.

4. Seismic Qualification Certificates: For control consoles, equipment cabinets and racks, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

5. Field quality-control reports.
6. Operation and maintenance data.

F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. Functional Description Of System
1. System Functions:
a. Selectively connect any zone to any available signal channel.
b. Selectively control sound from microphone outlets and other inputs.
c. "All-call" feature shall connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
d. Telephone paging adapter shall allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
e. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
f. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.

B. General Equipment And Material Requirements
1. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
2. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.

3. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch (483-mm) housing complying with TIA/EIA-310-D.
4. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.

C. Preamplifiers
1. Preamplifier: Separately mounted.
2. Preamplifier: Integral to power amplifier.
3. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
4. Total Harmonic Distortion: Less than 1 percent.
5. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.
6. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.
7. Minimum Noise Level: Minus 55 dB below rated output.
8. Controls: On-off, input levels, and master gain.

D. Power Amplifiers
1. Mounting: Console **OR** Rack, **as directed**.
2. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
3. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.
4. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
5. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
6. Output Regulation: Less than 2 dB from full to no load.
7. Controls: On-off, input levels, and low-cut filter.
8. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

E. Transfer To Standby Amplifier
1. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.

F. Microphones
1. Paging Microphone:
   a. Type: Dynamic, with cardioid **OR** omni, **as directed**, polar characteristic.
   b. Impedance: 150 ohms.
   c. Frequency Response: Uniform, 50 to 14,000 Hz.
   d. Output Level: Minus 58 dB, minimum.
   e. Finish: Satin chrome.
   f. Cable: C25J.
   g. Mounting: Desk stand with integral-locking, press-to-talk switch.

G. Volume Limiter/Compressor
1. Minimum Performance Requirements:
   a. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
   b. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
   c. Distortion: 1 percent, maximum.
   d. Rated Output: Minimum of plus 14 dB.
   e. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
   f. Rack mounting.

H. Control Console
1. Cabinet: Modular, desktop **OR** desk style, **as directed**; complying with TIA/EIA-310-D.

2. Housing: Steel, 0.0478 inch (1.2 mm) minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.
3. Panel for Equipment and Controls: Rack mounted.
4. Controls:
   a. Switching devices to select signal sources for distribution channels.
   b. Program selector switch to select source for each program channel.
   c. Switching devices to select zones for paging.
   d. All-call selector switch.
5. Indicators: A visual annunciation for each distribution channel to indicate source being used.
6. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
7. Spare Positions: 20 percent spare zone control and annunciation positions on console.
8. Microphone jack.

I. Equipment Cabinet
1. Comply with TIA/EIA-310-D.
2. House amplifiers and auxiliary equipment at each location.
3. Cabinet Housing:
   a. Constructed of 0.0478-inch (1.2-mm) steel, minimum, with front- and rear-locking doors and standard TIA/EIA-310-D-compliant, 19-inch (483-mm) racks.
   b. Arranged for floor or wall mounting as indicated.
   c. Sized to house all equipment indicated, plus spare capacity.
   d. Include 20 percent minimum spare capacity for future equipment in addition to space required for future cassette deck and CD player.
4. Power Provisions: A single switch in cabinet shall disconnect cabinet power distribution system and electrical outlets, which shall be uniformly spaced to accommodate ac-power cords for each item of equipment.
5. Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan shall be equipped with a filtered input vent and shall be connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switched; arranged to be powered when main cabinet power switch is on.

J. Equipment Rack
1. Racks: 19 inches (483 mm) standard, complying with TIA/EIA-310-D.
2. Power-Supply Connections: Compatible plugs and receptacles.
3. Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
4. Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
5. Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with socket for 5-A cartridge fuse for rack equipment power.
6. Service Light: At top rear of rack with an adjacent control switch.
7. Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c.; the full height of rack.
8. Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.
9. Spare Capacity: 20 percent in rack for future equipment.

K. Telephone Paging Adapter
1. Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
   a. Minimum Frequency Response: Flat, 200 to 2500 Hz.
   b. Impedance Matching: Adapter matches telephone line to public address equipment input.
   c. Rack mounting.

L. Tone Generator
1. Generator shall provide clock and program interface with public address and mass notification system.

2. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
3. Pitch Control: Chimes and tone.
4. Volume Control: All outputs.
5. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.
6. Mounting: Rack.

M. Monitor Panel
1. Monitor power amplifiers.
2. Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.
3. Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.
4. Mounting: Rack.

N. Loudspeakers
1. Cone-Type Loudspeakers:
   a. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
   b. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
   c. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.
   d. Minimum Dispersion Angle: 100 degrees.
   e. Rated Output Level: 10 W.
   f. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
   g. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.
   h. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.
2. Horn-Type Loudspeakers:
   a. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.
   b. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.
   c. Frequency Response: Within plus or minus 3 dB from 250 to 12,000 Hz.
   d. Dispersion Angle: 130 by 110 degrees.
   e. Mounting: Integral bracket.
   f. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.

O. Noise-Operated Gain Controller
1. Gain controller shall be designed to continuously sense space noise level and automatically adjust signal level to local speakers.
2. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
3. Level Adjustment Range: 20 dB minimum.
4. Maximum Distortion: 1 percent.
5. Control: Permits adjustment of sensing level of device.

P. Outlets
1. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.
   a. Wattage Rating: 10 W unless otherwise indicated.
   b. Attenuation per Step: 3 dB, with positive off position.
   c. Insertion Loss: 0.4 dB maximum.

d. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
e. Label: "PA Volume."

2. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.
3. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

Q. Battery Backup Power Unit
1. Unit shall be rack mounted, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
2. Unit shall supply public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.
3. Battery shall be on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
4. Unit shall automatically retransfer system to normal supply when normal power has been reestablished for three to five seconds continuously.

R. Conductors And Cables
1. Jacketed, twisted pair and twisted multipair, untinned solid copper.
a. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
b. Microphone Cables: Neoprene jacketed, not less than 2/64 inch (0.8 mm) thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
c. Plenum Cable: Listed and labeled for plenum installation.

S. Raceways
1. Conduit and Boxes: Comply with Division 16 Section "Raceways And Boxes". Flexible metal conduit shall not be used, unless directed otherwise.
a. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

1.3 EXECUTION

A. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**. Conceal raceway and cables except in unfinished spaces.
a. Install plenum cable in environmental air spaces, including plenum ceilings.
b. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways And Boxes".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

B. Installation Of Raceways
   1. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
   2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

C. Installation Of Cables
   1. Comply with NECA 1.
   2. General Cable Installation Requirements:
      a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
      b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
      c. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
      d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
      e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
      f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
   3. Open-Cable Installation:
      a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
      b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
      c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
   4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

D. Installation
   1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
   2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
   3. Equipment Cabinets and Racks:
      a. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
      b. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
      c. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.
   4. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
   5. Wall-Mounted Outlets: Flush mounted.
   6. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

7. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
8. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
9. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
10. Connect wiring according to Division 16 Section "Conductors And Cables".

E. Grounding
1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
3. Install grounding electrodes as specified in Division 16 Section "Grounding And Bonding".

F. Field Quality Control
1. Perform tests and inspections.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Schedule tests with at least seven days' advance notice of test performance.
   b. After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.
   c. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
   d. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
      1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
      2) Repeat test for each separately controlled zone of loudspeakers.
      3) Minimum acceptance ratio is 50 dB.
   e. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
   f. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
   g. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
   h. Signal Ground Test: Measure and report ground resistance at pubic address equipment signal ground. Comply with testing requirements specified in Division 16 Section "Grounding And Bonding".
3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.

4. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.
   a. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

END OF SECTION 16622a

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Task	Specification	Specification Description
16622	16265a	Central Battery Inverters

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SECTION 16720 - INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for intercommunications and program systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes: Manually switched and Microprocessor-switched intercommunications and program systems with the following components:
   a. Master stations.
   b. Speaker-microphone stations.
   c. Call-switch unit.
   d. All-call amplifier.
   e. Intercommunication amplifier.
   f. Paging amplifier.
   g. Loudspeakers/speaker microphones.
   h. Conductors and cables.
   i. Raceways.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For intercommunications and program systems. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring.
      1) Identify terminals to facilitate installation, operation, and maintenance.
      2) Single-line diagram showing interconnection of components.
      3) Cabling diagram showing cable routing.
3. Field quality-control reports.
4. Operation and maintenance data.

D. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.

1.2 PRODUCTS

A. Functional Description Of Manually Switched Systems
1. Master Station:
   a. Communicating selectively with other master and speaker-microphone stations by actuating selector switches.
   b. Communicating simultaneously with all other stations by actuating a single all-call switch.
   c. Communicating with individual stations in privacy.
   d. Including other master-station connections in a multiple-station conference call.
   e. Accessing separate paging speakers or groups of paging speakers by actuating selector switches.
   f. Overriding any conversation by a designated master station.

2. Speaker-Microphone Station:
   a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
   b. Communicating hands free.
   c. Calling master station by actuating call switch.
   d. Returning a busy signal to indicate that station is already in use.
   e. Being free of noise and distortion during operation and when in standby mode.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

B. Functional Description Of Microprocessor-Switched Systems
1. Master Station:
   a. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
   b. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
   c. Communicating with individual stations in privacy.
   d. Including other master-station connections in a multiple-station conference call.
   e. Accessing separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
   f. Overriding any conversation by a designated master station.
   g. Displaying selected station.
2. Speaker-Microphone Station:
   a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
   b. Communicating hands free.
   c. Calling master station by actuating call switch.
   d. Returning a busy signal to indicate that station is already in use.
   e. Being free of noise and distortion during operation and when in standby mode.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

C. General Requirements For Equipment And Materials
1. Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
2. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
3. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.
4. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

D. Master Station For Manually Switched Systems
1. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.
2. Volume Control: Regulates incoming-call volume.
3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
5. Speaker Microphone: Transmits and receives calls.
6. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
7. Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.

E. Master Station For Microprocessor-Switched Systems
   1. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.
   2. Volume Control: Regulates incoming-call volume.
   3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
   4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
   5. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
   6. Reset Control: Cancels call and resets system for next call.
   7. Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

F. Speaker-Microphone Stations
   1. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
   2. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
   3. Back Box: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.
   4. Speaker: 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.
   5. Tone Annunciation: Recurring momentary tone indicates incoming calls.
   6. Call Switch: Mount on faceplate. Permits calls to master station.
   7. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.
   8. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

G. Call-Switch Unit
   1. Enclosure: Single-gang box with stainless-steel faceplate.
   2. Call Switch: Momentary contact signals system that a call has been placed.
   3. Privacy Switch: Prevents transmission of sound signals from station to system.
   4. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.
   5. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.

H. All-Call Amplifier
   1. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
   2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
   3. Minimum Signal-to-Noise Ratio: 45 dB, at rated output.
   4. Frequency Response: Within plus or minus 3 dB from 70 to 12,000 Hz.
   5. Output Regulation: Maintains output level within 2 dB from full to no load.
   6. Input Sensitivity: Compatible with master stations and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
   7. Amplifier Protection: Prevents damage from shorted or open output.

I. Intercommunication Amplifier
   1. Minimum Output Power: 2 W; adequate for all functions.
   2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.
   3. Minimum Signal-to-Noise Ratio: 45 dB, at rated output.
   4. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.

5. Output Regulation: Maintains output level within 2 dB from full to no load.
6. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
7. Amplifier Protection: Prevents damage from shorted or open output.

J. Paging Amplifier
1. Input Voltage: 120-V ac, 60 Hz.
2. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.
3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
4. Total Harmonic Distortion: Less than 3 percent at rated power output from 70 to 12,000 Hz.
5. Output Regulation: Less than 2 dB from full to no load.
6. Controls: On-off, input levels, and low-cut filter.
7. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.
8. Amplifier Protection: Prevents damage from shorted or open output.
9. Output Circuit: 70-V line.

K. Cone-Type Loudspeakers/Speaker Microphones
1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
2. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
3. Minimum Dispersion Angle: 100 degrees.
4. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
5. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.
6. Baffle: For flush speakers, minimum thickness of 0.032-inch (0.8-mm) aluminum brushed to a satin sheen and lacquered **OR** with textured white finish, **as directed**.
7. Vandal-Proof, High-Strength Baffle: For flush **OR** surface, **as directed**,-mounted speakers, self-aging cast aluminum with tensile strength of 44,000 psi (303 MN/sq. m), 0.025-inch (0.65-mm) minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.
8. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.

L. Horn-Type Loudspeakers/Speaker Microphones
1. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.
2. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.
3. Minimum Power Rating of Driver: 15 W, continuous.
4. Minimum Dispersion Angle: 110 degrees.
5. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

M. Horn-Type Explosion-Proof Loudspeakers
1. Speakers shall be all-metal construction; complete with universal mounting brackets.
2. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.
3. Frequency Response: Within plus or minus 3 dB from 300 to 12,000 Hz.
4. Minimum Power Rating of Driver: 30 **OR** 60, **as directed**, W, continuous.
5. Minimum Dispersion Angle: 95 **OR** 60 by 120, **as directed**, degrees.
6. Line Transformer: Internally mounted and factory installed, power rating equal to speaker's, and at least four level taps.

N. Conductors And Cables
1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
3. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
   a. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

O. Raceways
1. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes".
2. Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 16 Section "Raceways And Boxes".
3. Intercommunication and Program System Raceways and Boxes: EMT **OR** ENT **OR** RNC **OR** Optical-fiber/communication raceways and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
4. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
5. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways And Boxes".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

B. Installation Of Raceways
1. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

C. Installation Of Cables
1. Comply with NECA 1.
2. General Requirements:
   a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
   b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
   c. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

3. Open-Cable Installation:

a. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.

b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.

c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

D. Installation

1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

3. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

4. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

5. Connect wiring according to Division 16 Section "Grounding And Bonding".

E. Grounding

1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

3. Install grounding electrodes as specified in Division 16 Section "Grounding And Bonding".

F. System Programming

1. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

G. Field Quality Control

1. Perform tests and inspections.

a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Tests and Inspections:

a. Schedule tests with at least seven days' advance notice of test performance.

b. After installing intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.

c. Operational Test: Test originating station-to-station, all-call, and page messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.

d. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
e. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
   1) Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at speakers or paging speakers.
   2) Repeat test for four speaker microphones and for each separately controlled zone of paging loudspeakers.
   3) Minimum acceptable ratio is 35 dB.
f. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each paging and all-call amplifier, and a minimum of two selected intercommunication amplifiers. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
g. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at three locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.
h. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
i. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Division 16 Section "Grounding And Bonding".

3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
4. Intercommunications and program systems will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 16720

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Task	Specification	Specification Description
16720	16140	Wiring Devices
16775	16120c	Conductors And Cables
16775	16720	Intercommunications and Program Systems

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SECTION 16795 - LOOSE-TUBE GEL-FILLED FIBER OPTIC CABLES

GENERAL

Description Of Work

1. This specification covers the furnishing and installation of loose-tube gel-filled fiber optic cables. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

Shop Drawings And Samples

2. The following shall be submitted:
   a. Complete bill of materials.
   b. Drawings indicating the locations of all pull boxes with station numbers.
   c. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.
   d. Cable pulling calculations for all conduit runs. Indicate on the submittal any additional pull boxes that are required, including station number and a written description, of the location.
   e. A cable pulling and splicing work plan shall be submitted a minimum of 45 days prior to the planned initiation of cable pulling. The pulling plan and pull tension calculations may be prepared by using a software program such as Pull-Planner 2000 by American Polywater Corporation. The cable pulling and splicing work plan must be approved a minimum of 15 days prior to pulling cable. Work plan shall include the following:
      1) Pull tension calculations
      2) Calculated amount of lubrication required
      3) Detailed description of pull operation methods for all conduit runs

Quality Assurance

3. All work described in this section shall meet or exceed the applicable provisions of the following documents:
   a. ANSI C8.471983, American National Standard for Polyolefin Insulated Thermoplastic Jacketed Communication Cables.
   b. EIA-455 (addendum 1 through 5) Standard Test Procedures for Fiber Optics, Cables, Transducers, Connecting and Terminating Devices.
   c. EIA-455-27A, Method of Measuring (Uncoated) Diameter of Optical Waveguide Fibers.
   d. EIA-455-28A, Method For Measuring Tensile Failure Point of Optical Waveguide Fibers.
   e. EIA-455-34, Interconnection Device Insertion Loss Test.
   f. EIA-455-89, Fiber Optic Cable Jacket Elongation and Tensile Strength.

Warranty

4. The Contractor shall provide an unconditional warranty on all installed cable for a minimum period of two (2) years.

PRODUCTS

Materials

5. Fiber Optic Cable - 24 strand
   a. Cable type: Outdoor Plant Stranded Loose-Tube, Gel-Filled Fiber Optic Cable, Corning Altos 024RW4-14101A20 or Lucent Lightpack 7D1X-024-BXD.
   b. Number of fibers: 24 fibers.
   c. Buffer Tubes: All optical fibers shall be placed inside a loose buffer tube. The optical cable shall contain three buffer tubes, numbered 1, 2, and 3. The tubes shall be color coded according to the table below:

Buffer Tube Number	Buffer Tube Color
1	Blue
2	Orange
3	Green

d. Each buffer tube shall contain 8 singlemode fibers. Each fiber shall be numbered and distinguishable by means of the color coding established in the main body of the specification.
e. The colors of the individual fibers shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
f. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.
g. Filler may be included in the cable core composition to lend symmetry to the cable cross-section where needed.
h. A central anti-buckling member shall be included into the cable to prevent buckling of the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.
i. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
j. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.
k. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.
l. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dialectic with low shrinkage.
m. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
n. The all-dielectric cable shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.
o. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

6. Fiber Optic Cable - 36 Strand
   a. Cable type: Outdoor Plant Stranded Loose-Tube, Gel-Filled Fiber Optic Cable, Corning Altos 036RW4-14101A20 or Lucent Lightpack 7D1X-036-BXD.
   b. Number of fibers: 36 fibers.
   c. Buffer Tubes: All optical fibers shall be placed inside a loose buffer tube. The optical cable shall contain three buffer tubes, numbered 1, 2, and 3. The tubes shall be color coded according to the table below:

Buffer Tube Number	Buffer Tube Color
1	Blue
2	Orange
3	Green

   d. Each buffer tube shall contain 12 single mode fibers. Each fiber shall be numbered and distinguishable by means of the color coding established in the main body of the specification.

e. The colors of the individual fibers shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
f. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.
g. Filler may be included in the cable core composition to lend symmetry to the cable cross-section where needed.
h. A central anti-buckling member shall be included into the cable to prevent buckling of the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.
i. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
j. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.
k. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt arid foreign matter and shall be readily removable with conventional nontoxic solvents.
l. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dialectic with low shrinkage.
m. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
n. The all-dielectric cable shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.
o. The cable shall contain at least one ripcord under the sheath for easy sheath removal.

7. Fan-Out Termination for Loose Tube Cables
   a. Individual fibers within the loose tube cable require handling protection inside the termination cabinets. Fan-out kits shall be installed in the patch panel enclosures to transition the loose tube fibers to ruggedized tight-buffered fiber pigtail cables. Fan-out tubes or furcation kits shall not be used. Optical fusion splices shall connect the loose tube fibers to the tight-buffered pigtail cables. The optical splice loss shall comply with the specifications for optical splices. Splice protection sleeves shall be employed on all splices to protect the splices. A wall-mountable splice center shall house the splices and serve to fully protect excess lengths of loose tube fibers from exposure.
   b. The tight-buffered pigtails shall be terminated with ST connectors as specified.
8. Fan-out Pigtail Cable Specifications
   a. Singlemode fiber (Corning SMF-28) shall be used in the pigtails. Optical characteristics shall comply with the optical fiber performance specifications.

Buffer material	Thermoplastic
Buffer O.D.	900 um
Strength Member	Kevlar
Jacket Material	PVC
Jacket O.D.	3.0 mm
Temperature Range	-20 to +70 C

9. Fiber Optic Termination Patch Panels:
   a. Where shown on the plans or in the Appendix, the fiber optic cable shall terminate inside a communications cabinet on a termination patch panel. All fiber sub-cables within the cable shall be terminated with "ST™ compatible" connectors. The patch panel shall have a 24-fiber capacity, and shall facilitate fiber-optic cable cross-connection between outside plant

cables and opto-electronic interface equipment cabling. The patch panel shall contain "ST™" type bayonet couplings. All unused couplings shall have protective dust covers. Factory-terminated, tight-buffered, aramid-reinforced fiber optic jumper assemblies or interconnect cables, standard 3.0-mm O.D., shall connect the optical cable terminations to the patch panel couplings.

b. The termination panel shall be equipped with a suitable means for routing and securing of cables and shall provide a suitable means of protection for the mounted fiber connectors, to prevent damage to fibers arid connectors during all regular operation and maintenance functions. Bend diameters on cable fibers and jumpers must be greater than four (4) inches at all times to ensure optical and mechanical integrity of the optical fibers.

10. Optical Connectors
    a. All connectors shall be field-installable and perfectly matched to the cable used. The connectors shall provide tight fitting termination, to the cladding and buffer coating. Epoxy-based or "hot melt " adhesives shall be used to bond the fiber and buffer to the connector ferrule and body prior to polishing the end face. No dry-termination or "quick crimp" connectors are allowed.
    b. After termination with connectors, the fiber ends must be visually inspected at a magnification of not less than 100 power to check for cracks or pits in the end face of the fiber. If any irregularities found cannot be removed by further polishing, the entire process must be redone by cutting off and disposing the connector body.
    c. Connectors shall have a maximum allowable connection loss of 0.3 dB per mated pair, as measured per EIA-455-34. No index-matching gel is to be used, dry interfaces only. Singlemode connectors shall be capable of field installation on 9/125 micron fibers with 900 micron buffers (OD).
    d. Each connector shall be of the industry standard ST type compatible, designed for singlemode tolerances, and shall meet or exceed the applicable provisions of EIA-455-5, 455-2A, and 455-34, and shall be capable of 100 repeated matings with a maximum loss increase of 0.1 dB. Connectors shall incorporate a key-way design and shall have a zirconia ceramic ferrule. Connector bodies and couplings shall be made of corrosion-resistant and oxidation-resistant materials, such as nickel plated zinc, designed to operate in humid environments without degradation of surface finishes.
11. Splice Closures:
    a. Splice closures shall be of the re-enterable type, with an external moisture-proof shell, inner closure and encapsulant.
    b. Closure shall have removable interior splice trays.
    c. Closures shall be Corning Cable Systems (Siecor) type SCN or equal.

EXECUTION

Fiber Optic Cable Installation

12. General:
    a. The Contractor shall determine a suitable cable installation method to ensure that all cable installation requirements shall be met in all conduit sections. All work shall be carried out in accordance and consistent with the highest standards of quality and craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections; the finished appearance of the installation; as well as the accuracy and completeness of the documentation.
    b. The Contractor shall make a physical survey of the project site for the purpose of establishing the exact cable routing and cutting lengths prior to the commencement of any work or committing any materials.
    c. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the the Owner notified.

d. Precautions shall be taken during installation to prevent the cable from being kinked or crushed. Crushed or kinked cable shall be replaced with new cable. As the cable is pulled into the conduit system, it shall be sufficiently lubricated with a lubricant that shall be the water-based type and approved by the cable manufacturer. Lubricant shall be applied at a rate to provide a continuous 10-mil coating, as recommended by the manufacturer. Lubricant shall be Polywater F® manufactured by American Polywater, or approved equivalent.

e. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched or exceeds manufacturer's specifications.

f. The pulling of the cable shall be hand assisted at each handhole or pullbox. When pulling through intermediate pullboxes, the cable shall be placed on the ground near the pullbox and care taken to prevent damage by vehicles or other objects. The cable shall not be crushed, kinked or forced around a sharp corner. A minimum of 3 foot slack shall be left in each pullbox and enough left at each end of the cable to allow proper cable termination.

13. Fiber optic cables shall be installed in continuous lengths without intermediate splices throughout the project. Cable installation personnel shall be familiar with the manufacturer's recommended procedures including, but not limited to the following:

a. Proper attachment to the cable strength elements for pulling during installation. Depending on cable design, this will involve direct attachment to internal strength members or attaching an external "Kellums" or split mesh grip using a 600 lb breakaway swivel.

b. Cable tensile limitations and tension monitoring procedures.

c. Cable bending radius limitations.

d. Cable twisting limitations.

14. The Contractor shall comply with the cable manufacturer's recommended installation procedures at all times. Cable installation procedures shall conform to Belcore guidelines.

15. To accommodate long continuous installation lengths, bi-directional "center pull" techniques for pulling of the fiber optic cable is acceptable and shall be implemented as follows:

a. From the midpoint, pull the fiber optic cable into the conduit from the shipping reel in accordance with the manufacturer's specifications.

b. When this portion of the pull is complete, the remainder of the cable must be removed from the reel to make the inside end available for pulling in the opposite direction.

c. This is accomplished by hand pulling the cable from the reel and laying into large "figure eight" loops on the ground.

d. The purpose of the figure eight pattern is to avoid cable tangling and kinking.

e. The loops shall be laid carefully one upon the other (to prevent subsequent tangling) and shall be in a protected area.

f. The inside reel end of the cable is then available for installation.

g. In some cases, it may be necessary to set up a winch at an intermediate cable vault.

h. The required length of cable shall be pulled to that point, and brought out of the cable vault and coiled into a figure eight.

i. The figure eight is then turned over to gain access to the free cable end. This can then be reinserted into the duct system for installation into the next section.

16. At pullboxes, the Contractor shall provide 30 feet of cable slack. The fiber optic cable shall be coiled and secured with cable ties in the pullbox. The Contractor shall ensure that the minimum bending radius of the fiber optic cable is not compromised when preparing this stored cable slack.

17. The pulling eye/sheath termination hardware on the fiber optic cables shall not be pulled over any sheave blocks.

18. When power equipment is used to install fiber optic cabling, the pulling speed shall not exceed 30 meters per minute. The pulling tension, bending radius and twist limitation for fiber optic cable shall not be exceeded under any circumstances.

19. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or loadcell instruments.

a. All pulls shall be documented by a graph which is annotated with the following information:

1) Reel number

2) Station from and station to

3) Date and tune
4) Explanations of abnormalities in readings or interruptions
5) Sign-off by Contractor and the Owner

b. Under no conditions shall the FOC be left exposed or unattended.

20. Repairs: Repair of cable jacket will not be permitted. Jacket damage will require removal and re-installation of a new cable run at the Contractor's expense.

21. Splicing:
    a. Splicing of fiber optic cable shall not be permitted except in emergency conditions or as specified on the plans or in the special conditions for a specified project. Fiber optic cable runs and required looping of the cable shall be provided in one continuous length. When splicing is authorized by the the Owner, splicing shall be by trained, authorized persons only. Any allowed splicing of fiber optic cable shall be by fusion splice only, no mechanical splices are permitted.
    b. All fusion splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.
    c. Spices shall be made in pullboxes and shall use re-enterable splice closures.
    d. The average splice loss shall be 0.1 dB or less per splice. The average splice loss is defined as the summation of the loss as measured in both directions using an optical time domain reflectometer (OTDR) through the fusion splice, divided by two. No individual splice loss measured in a single direction shall exceed 0.15 dB.
    e. Upon completion of the splicing operation, all waste material shall be deposited in suitable containers, removed from the job site, arid disposed of in an environmentally acceptable manner.

22. After the cables are installed and spliced, they shall be racked and all conduits sealed. A minimum of 30 feet of FOC shall be stored at each end of one splice. Racking shall conform to the following:
    a. Cables shall be loosely secured in racked position with Ty-Raps or equal.
    b. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the cables in at least two locations in each handhole. Tags shall be by Brady or Thomas & Betts.
    c. All coiled cable shall be suitably protected to prevent damage to the cable and fibers. Racking shall include securing cables to brackets and racking hardware that extend from the sidewalls of the handhole.
    d. When all cables at each handhole are securely racked, unused conduits and void areas around conduit containing cables shall be sealed.

Cable Protection During Installation

23. All fiber optic cable shall be pulled in conduit except as specified on the plans. Care shall be exercised during cable pulls through conduit bends and looping in pull boxes.

24. To reduce the possibility of damage to the outer jacket of the fiber optic cable, protective measures shall be used when the cable is installed. The requirements herein shall be followed, but does not limit the installation to only those identified. The purpose of the installation specifications is to ensure protection, of the fiber optic cable when it is installed. Other protective measures not specified herein may be taken during installation if it will ensure protection of the cable.

25. A cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it off the reel and into the duct. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the the Owner notified.

26. Precautions shall be taken during installation to prevent the cable from being kinked, crushed or twisted. A pulling eye shall be attached to the cable end and be used to pull the cable through the duct and conduit system. As the cable is pulled off the reel and into the cable feeder guide, it shall

be sufficiently lubricated with a lubricant that shall be of the water based type and approved by the cable manufacturer.

27. Dynamometers or break away pulling swings shall be used to ensure the pulling line tension does not exceed the installation tension values specified by the cable manufacturer. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched. Maximum allowable cable strain during installation shall be less than 0.75%.
28. The pulling of the cable shall be hand assisted at each handhole or pullbox. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination.
29. The cable shall be looped in all pull boxes as noted on the plans to provide approximately thirty (30) feet of extra cable in the pull box. At termination points, such as at cabinets or computers, a thirty (30) foot loop shall also be provided wherever space permits.
30. Cable Marking: At each pullbox and at each cabinet, the cable shall be visibly marked with yellow warning tape as follows:

"CAUTION - FIBER OPTIC CABLE"

Fiber Optic Cable Testing

31. General: The Contractor shall perform pre-installation and post-installation FOC tests. The the Owner shall be notified a minimum of 10 days in advance so that these tests are witnessed. All test equipment shall be traceable to NIST standards.
32. Test equipment: The Contractor, shall use the following to perform pre-installation and post-installation FOC tests:
    a. Optical time domain reflectometer (OTDR). The OTDR shall be laser precision, ALT Inc. MODEL 5200 LRFL, or equal.
33. Pre-installation tests
    a. The purpose of these tests is to perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes.
    b. Prior to removal of each cable from the delivery reel, all optical fibers within the cables shall be tested by the Contractor using an OTDR. The OTDR tests shall consist of end-to-end length and fiber attenuation (dB/km) measurements to ensure proper performance of the fiber optic cable. The tests shall be performed from both ends of each fiber to ensure complete fiber continuity within the cable structure.
    c. Pre-installation, "on-reel" test results shall be compared with the manufacturer's test report delivered with the cable. Gross dissimilarities shall be noted and remedied between the Contractor and manufacturer. In all cases, all fibers must meet the optical attenuation specifications prior to cable installation.
    d. The Contractor shall perform tests on all reels of cable. The the Owner shall be notified a minimum of 15 days prior to any test.
    e. The Contractor shall document each test and submit the report to the the Owner for review. Documentation shall consist of both hard copy and 3-1/2 inch electronic disk complete with all application software.
    f. Cable shall not be installed until the the Owner has reviewed the test report.
    g. Maximum allowable attenuation is 0.5 dB/km at 1310 and 1550 nm.
34. Post-installation tests: After FOC has been installed the following tests shall be performed:
    a. A recording OTDR shall be used to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with a 1310 nm and 1550 nm light source for the single mode fiber (SMF). The OTDR shall have an X-Y plotter to provide a hard copy record of each trace of each fiber: The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of 30 feet or more to display the required cable section.
    b. The OTDR shall be calibrated for the correct index of refraction to provide proper length measurement for the known length of reference fiber.

c. A transmission test shall be performed with the use of a 1310 and 1550 nm stabilized light sources and 1310 nm/1550 nm power meters for SMF. This test shall be conducted in both directions on each fiber of each cable.

d. Hard and electronic copy of test documentation shall be submitted to the the Owner. The documentation shall include the trace plot, index, dB/km loss, cable length, date and time of test, wavelength, pulse width, the test site, cable ID, fiber number and type, and operator's initials. The Contractor shall compare the pre-installation test results to the post-installation results. If a deviation of greater than one dB occurs, the the Owner shall be notified in writing by the Contractor, and the cable shall be removed and replaced at no additional cost to the Owner.

e. Upon completion of the previous tests all FOC coils shall be secured with ends capped to prevent intrusion of dirt and water.

35. Required OTDR Trace Information:

a. All traces shall display the entire length of cable under test, highlighting any localized loss discontinuities (installation-induced losses and/or connector losses). The trace shall display fiber length (in kilofeet), fiber loss (dB), and average fiber attenuation (in dB/km) as measured between two markers placed as near to the opposite ends of the fiber under test as is possible while still allowing an accurate reading. Care shall be taken to ensure that the markers are placed in the linear region of the trace: away from the front-end response and far-end Fresnel reflection spike. Time averaging shall be used to improve the display signal to noise ratio. The pulse width of the OTDR shall be set to a sufficient width to provide adequate injected power to measure the entire length the fiber under test.

b. If connectors exist in the cable under test, then two traces shall be recorded. One trace shall record the fiber loss (dB) and average attenuation (dB/km) of the entire cable segment under test, including connectors. The second trace shall display a magnified view of the connector regions, revealing the connector losses (dB). All connector losses shall be measured using the 5-point splice loss measurement technique.

c. The OTDR trace shall also include the following information:

1) The date and time of the test
2) The cable ID number
3) The cable segment ID number
4) The fiber color or sub-cable number
5) Launch point connector number
6) The optical wavelength used for the test
7) The refractive index setting of the OTDR
8) The pulse width setting of the OTDR
9) The averaging interval of the test

END OF SECTION 16795

SECTION 16820 - EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for educational intercommunications and program systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section Includes: Manually switched intercommunications, Microprocessor-switched intercommunications, Microprocessor-switched telephone/intercommunications and program systems with the following components:
   a. Master stations.
   b. Call control console.
   c. Speaker-microphone stations.
   d. Call-switch unit.
   e. All-call amplifier.
   f. Intercommunication amplifier.
   g. Paging amplifier.
   h. Loudspeakers/speaker microphones.
   i. Conductors and cables.
   j. Raceways.

C. Submittals
1. Product Data: For each type of product indicated.
2. Shop Drawings: For educational intercommunications and program systems. Include plans, elevations, sections, details, and attachments to other work.
   a. Wiring Diagrams: For power, signal, and control wiring.
      1) Identify terminals to facilitate installation, operation, and maintenance.
      2) Single-line diagram showing interconnection of components.
      3) Cabling diagram showing cable routing.
3. Field quality-control reports.
4. Operation and maintenance data.

D. Quality Assurance
1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
3. Comply with NFPA 70.

1.2 PRODUCTS

A. Functional Description Of Manually Switched Systems
1. Master Station:
   a. Communicating selectively with other master and speaker-microphone stations by actuating selector switches.
   b. Communicating simultaneously with all other stations by actuating a single all-call switch.
   c. Communicating with individual stations in privacy.
   d. Including other master-station connections in a multiple-station conference call.

e. Accessing separate paging speakers or groups of paging speakers by actuating selector switches.
f. Overriding any conversation by a designated master station.

2. Speaker-Microphone Station:
   a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
   b. Communicating hands free.
   c. Calling master station by actuating call switch.
   d. Returning a busy signal to indicate that station is already in use.
   e. Being free of noise and distortion during operation and when in standby mode.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

B. Functional Description Of Microprocessor-Switched Systems
1. Master Station:
   a. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
   b. Communicating with individual stations in privacy.
   c. Communicating on a minimum of three voice channels with up to two simultaneous conversations between master stations and one conversation between a master station and a speaker-microphone station.
   d. Increasing the number of conversation channels by adding a module in central-control cabinet.
   e. Including up to three other station connections in a conference call.
   f. Accessing separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
   g. Overriding any conversation by a designated master station.
   h. Displaying selected station.
   i. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
   j. Automatically controlling gain to ensure constant intercom speech level.
   k. Controlling the simultaneous distribution of program material to various combinations of speaker-microphone stations or groups over two program channels by using keypad to control sources and distribute programs.
   l. Operating and correcting secondary clocks and controlling class-change signals to speakers and bells by using keypad.
   m. User-programmable features include the following:
      1) Station calling by room number.
      2) Room station call-in priority levels.
      3) Clock signal schedule functions.
      4) Schedule characteristics of audible signals.
      5) Call-in tone characteristic.
      6) Precedence among master stations as destinations for incoming calls from room stations.
      7) Grouping of rooms and speakers into zones for paging and program distribution purposes.
2. Speaker-Microphone Station:
   a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
   b. Communicating hands free.
   c. Calling master station by actuating call switch.
   d. Returning a busy signal to indicate that station is already in use.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

C. Functional Description Of Telephone/Intercommunication Systems

1. Integrated central system with the following:
   a. Direct-dial, full duplex private telephone communications between all locations equipped with telephones. Call initiation among master stations and between master and remote stations by dialing station's number on a 12-digit keypad.
   b. 16 channels for unrestricted simultaneous communications.
   c. Initial system operation with <**Insert number**> master and remote stations, expandable to 360 stations.
   d. Direct-dial, two-way amplified voice intercommunication between master telephones and remote stations without use of press-to-talk or talk-listen switches.
   e. Automatic queuing for intercommunication channels, with automatic call waiting.
   f. Call transfer among master stations.
   g. Display of selected station and answering calling station by pressing a single "response button."
   h. Simultaneous communication with other stations on system by dialing a designated number on a 12-digit keypad.
   i. Automatic gain control to ensure constant intercom speech level.
   j. Simultaneous distribution of emergency announcements to all locations equipped with speakers by dialing a predetermined code number.
   k. User-selectable facility for providing selected telephones with dial tone.
   l. User-selectable facility for permitting linkage of selected stations to media retrieval center and for permitting on- and off-premise computer linkage.
   m. Assignment of speaker locations within any one or more of eight zones for zone paging or time signal reception.
   n. Digital readout displays on which up to three incoming calls are displayed with additional calls stored for subsequent display.
   o. Off-site diagnostics through a serial data port on central-control station.
   p. Control of simultaneous distribution of program material to various combinations of remote stations or groups by using keypad to control sources and distribute programs.
   q. Operation and correction of secondary clocks and control of class-change signals to speakers and bells by using keypad.
   r. User-programmable features include the following:
      1) Station calling by room number.
      2) Room station call-in priority levels.
      3) Clock signal schedule functions.
      4) Schedule characteristics of audible signals.
      5) Call-in tone characteristic.
      6) Precedence among master stations as destinations for incoming calls from room stations.
      7) Grouping rooms and speakers into zones for paging and program distribution purposes.
   s. Telephone interconnect features include the following:
      1) Direct connection to central office trunk lines with initial system wiring for <**Insert number**> trunk lines.
      2) Routing of outside trunk lines for "attendant answer incoming" and "direct inward line" functions.
      3) Station programming for access to outside trunk lines to be any of the following:
         a) Totally unrestricted access.
         b) Restricted access.
         c) No access.
      4) System programming to allow or disallow local prefixes, and to authorize access for as many as three area codes.
      5) Discriminating ringing for identifying internal and outside calls.
      6) Circular hunting for outside trunks to prevent excess usage of any one trunk.
      7) Direct connection of a single trunk to designated telephone with transfer to attendant if unanswered.

8) Call parking allowing paged party to remotely pick up outside call from any master station.
9) Night-answer mode to allow one or all of the following:
   a) Incoming call transferred to predetermined extension.
   b) Tone transmitted to speakers to notify key personnel to answer telephone.
   c) Dial tone to remote stations to allow answering call from all locations.
10) Call control console to do as follows:
   a) Identify, answer, and route incoming outside calls, with reminder and recall features.
   b) Directly access outside trunk lines.
   c) Hold, park, and transfer calls.
   d) Screen outside calls.

2. Remote Stations:
   a. Speaker-Microphone Station:
      1) Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
      2) Communicating hands free.
      3) Calling master station by actuating call switch.
      4) Returning a busy signal to indicate that station is already in use.
3. Speakers: Free of noise and distortion during operation and when in standby mode.

D. General Requirements For Equipment And Materials
1. Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
2. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
3. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz. Comply with UL 813.
4. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

E. Master Station For Manually Switched Systems
1. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.
2. Volume Control: Regulates incoming-call volume.
3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
5. Speaker Microphone: Transmits and receives calls.
   a. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
6. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
7. Central-Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.

F. Master Station For Microprocessor-Switched Systems
1. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.
2. Volume Control: Regulates incoming-call volume.
3. Tone Annunciation: Momentary audible tone signal announces incoming calls.
4. Lamp Annunciation: Identifies calling stations and stations in use. Lamp remains on until call is answered.

5. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.
   a. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
6. Link Button: To transfer calls.
7. Reset Control: Cancels call and resets system for next call.
8. Digital Display: 16-digit alphanumeric LCD readout to register up to four three-digit station numbers.
9. Central-Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

G. Call Control Console
1. Microprocessor-based instrument to process outside and internal calls with a 12-digit keypad selector.
2. 20-character alphanumeric display for the following:
   a. Simultaneous display of up to three calling stations plus last station dialed.
   b. Display of calls in order received with emergency calls taking precedence on the display.
   c. Review of calls stored in groups of four.
   d. Display of prompt messages to assist in system operation.
3. Programmable Keys: Minimum of 20 with LED indicators for ringing/busy status; programmable for trunk and operator functions.
4. Transfer Button: Calls to busy extensions and unanswered calls automatically returned to call control console.
5. Hold Button: With reminder feature every 30 seconds for parked calls or calls placed on hold.
6. Release Button: For use with parked calls or calls placed on hold.
7. Page Button: For engaging system paging functions.
8. Programmable for night answer, remote answer, and remote pickup features.
9. Programmable for distribution of emergency announcements, all-page announcements, zone-page announcements, and emergency/evacuation alert.
10. Central-Control Cabinet Equipment: Central switching equipment, central office adapter module, line link modules, power supplies, chassis adapters, and other switching and control devices required for trunk and internal conversation channels and control functions.

H. Speaker-Microphone Stations
1. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
2. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
3. Back Box: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.
4. Speaker: Minimum axial sensitivity shall be 91 dB at one meter, with 1-W input. Voice coil shall be not less than 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.
5. Tone Annunciation: Recurring momentary tone indicates incoming calls.
6. Call Switch: Mount on faceplate. Permits calls to master station.
7. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

I. Call-Switch Unit
1. Enclosure: Single-gang box with stainless-steel faceplate.
2. Call Switch: Momentary contact signals system that a call has been placed.
3. Privacy Switch: Prevents transmission of sound signals from station to system.
4. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.

J. All-Call Amplifier
1. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.

2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
4. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
5. Output Regulation: Maintains output level within 2 dB from full to no load.
6. Input Sensitivity: Compatible with master stations and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
7. Amplifier Protection: Prevents damage from shorted or open output.

K. Intercommunication Amplifier
1. Minimum Output Power: 15 W; adequate for all functions.
2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.
3. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.
4. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.
5. Output Regulation: Maintains output level within 2 dB from full to no load.
6. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in master stations, speaker microphones, or handset transmitters.
7. Amplifier Protection: Prevents damage from shorted or open output.

L. Paging Amplifier
1. Input Voltage: 120-V ac, 60 Hz.
2. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.
3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
4. Total Harmonic Distortion: Less than 3 percent at rated output power from 70 to 12,000 Hz.
5. Output Regulation: Less than 2 dB from full to no load.
6. Controls: On-off, input levels, and low-cut filter.
7. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.
8. Amplifier Protection: Prevents damage from shorted or open output.

M. Cone-Type Loudspeakers/Speaker Microphones
1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
2. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
3. Minimum Dispersion Angle: 100 degrees.
4. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
5. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.
6. Baffle: For flush speakers, minimum thickness of 0.032-inch (0.8-mm) aluminum brushed to a satin sheen and lacquered **OR** with textured white finish, **as directed**.
7. Vandal-Proof, High-Strength Baffle: For flush **OR** surface, **as directed**,-mounted speakers, self-aging cast aluminum with tensile strength of 44,000 psi (303 MN/sq. m), 0.025-inch (0.65-mm) minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.
8. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.

N. Horn-Type Loudspeakers/Speaker Microphones
1. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.

2. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.
3. Minimum Power Rating of Driver: 15 W, continuous.
4. Minimum Dispersion Angle: 110 degrees.
5. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

O. Conductors And Cables
1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
3. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
   a. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

P. Raceways
1. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 16 Section "Raceways And Boxes".
2. Educational Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 16 Section "Raceways And Boxes".
3. Educational Intercommunication and Program System Raceways and Boxes: EMT **OR** ENT **OR** RNC **OR** Optical-fiber/communication raceways and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
4. Outlet boxes shall be not less than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
5. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Wiring Methods
1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**. Conceal raceway and cables except in unfinished spaces.
   a. Install plenum cable in environmental air spaces, including plenum ceilings.
   b. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways And Boxes".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

B. Installation Of Raceways
1. Comply with requirements in Division 16 Section "Raceways And Boxes" for installation of conduits and wireways.
2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

C. Installation Of Cables
1. Comply with NECA 1.
2. General Requirements:
   a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.

b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
c. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

3. Open-Cable Installation:
a. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

D. Installation
1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
3. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
4. Connect wiring according to Division 16 Section "Grounding And Bonding".

E. Grounding
1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
3. Install grounding electrodes as specified in Division 16 Section "Grounding And Bonding".

F. System Programming
1. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

G. Field Quality Control
1. Perform tests and inspections.
a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
a. Schedule tests with at least seven days' advance notice of test performance.

b. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.

c. Operational Test: Test originating station-to-station **OR** originating station-to-station, all-call, and page, **as directed**, messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.

d. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, **as directed**, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.

e. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

1) Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at paging, **as directed**, speakers.

2) Repeat test for three speaker microphones, one master station microphone, and for each separately controlled zone of paging loudspeakers.

3) Minimum acceptable ratio is 45 dB.

f. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom **OR** intercom, paging, and all-call amplifier, **as directed**. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.

g. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.

h. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.

i. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Division 16 Section "Grounding And Bonding".

3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.

4. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.

5. Prepare test and inspection reports.

END OF SECTION 16820

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Task	Specification	Specification Description
16820	16622a	Public Address and Mass Notification Systems
16915	15910a	Enclosed Controllers

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SECTION 16920 - POWER FACTOR CORRECTION CAPACITORS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for power factor correction capacitors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. Section includes power and automatic power factor correction equipment rated 600 V and less.

C. Performance Requirements
1. Seismic Performance: Power factor correction equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Submittals
1. Product Data: For each type of product indicated. Include dimensions, operating characteristics of multiple capacitor cells or elements, and data on features, ratings, and performance.
2. Shop Drawings: For automatic power factor correction units.
a. Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.
b. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For capacitors, accessories, and components, from manufacturer.
a. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment: Identify center of gravity and locate and describe mounting and anchorage provisions.
c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Field quality-control reports.
6. Operation and Maintenance Data: For equipment to include in emergency, operation, and maintenance manuals. Include the following:
a. Lists of spare parts and replacement components recommended for storage at Project site.
b. Detailed instructions covering operation under both normal and abnormal conditions.
7. Warranty: Sample of special warranty.

E. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with IEEE 18 and NEMA CP 1.
4. Comply with NFPA 70.

F. Coordination

1. Coordinate sensor-communication module package with data network and with monitoring equipment specified in Division 16 Section "Electrical Power Monitoring And Control" for successful transmission and remote readout of remote monitoring data specified in this Section.

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace capacitor-bank components that fail in materials or workmanship within five years from date of Substantial Completion.

1.2 PRODUCTS

A. Capacitors, General
1. Comply with UL 810.
2. Service Conditions: Capacitor equipment suitable for the following conditions:
   a. Operating Temperature: Minus 40 to plus 115 deg F (Minus 40 to plus 46 deg C).
   b. Maximum Altitude: 6000 feet (1800 m).
   c. Humidity: 0 to 95 percent, noncondensing.
3. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.
4. Cells: Dry metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.
5. Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

B. Fixed Capacitors
1. Description: Factory wired, ready for field connection to external circuits at a single set of pressure terminals. Comply with UL 810.
2. Fuses: Current-limiting, noninterchangeable type; factory installed in each phase and located within the equipment enclosure. Features include the following:
   a. Interrupting Capacity: 100,000 **OR** 200,000, **as directed**, A
   b. Fuse Ratings and Characteristics: As recommended by capacitor manufacturer.
   c. Neon Indicator Lamp for Each Fuse: Connect to illuminate when fuse has opened, but is still in place, and locate so it is visible from outside the enclosure.
3. Discharge Resistors: Factory installed and wired.
4. Enclosure: NEMA 250, steel **OR** aluminum, **as directed**, arranged to contain the fluid leakage from capacitor cells; factory equipped with mounting brackets suitable for type of mounting indicated.
   a. Indoor Enclosures: NEMA 250, Type 12 or as indicated.
      OR
      Outdoor Enclosures: NEMA 250, Type 3R or as indicated.
      OR
      Outdoor Enclosures: NEMA 250, Type 4, equipped with watertight conduit connections.

C. Automatic Power Factor Correction Units
1. Description: Capacitors, contactors, controls, and accessories factory installed in independent enclosures **OR** motor-control center, with a connection to motor-control center bus, **as directed**, complying with NEMA ICS 2. Comply with UL 810.
2. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Provide number of switching steps indicated on the Three-Phase Capacitor-Bank Schedule.
3. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.

4. Main Circuit Breaker: Thermal-magnetic, inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Operable from outside the enclosure to disconnect the unit.
5. Controls: Solid-state, microprocessor-based controls, including the following:
   a. Undervoltage relay that interrupts capacitor switching and disconnects capacitors for power-supply interruptions longer than 15 minutes.
   b. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.
6. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.
7. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.
   a. Spare-Fuse Cabinet: Identified and compartmented steel box **OR** cabinet with hinged lockable door, **as directed**.
8. Discharge Resistors: Factory installed and wired.
   OR
   Inductors: Air-core type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.
9. Precharge Capacitor Circuit: Resistive, precharge circuit to charge capacitors prior to switching and to limit switching surges to within contactor ratings.
10. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 12, **as directed**, steel or aluminum, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.
    a. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.
11. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure, indicating the following:
    a. Target and actual power factors accurate to plus or minus 1 percent of reading.
    b. Steps energized.
    c. Step reconnection delay.
    d. Real and reactive currents.
    e. Voltage total harmonic distortion.
    f. Alarm codes.
12. System Alarms: Alarm relay and local display indication of the following conditions:
    a. Low power factor.
    b. Leading power factor.
    c. Frequency not detected.
    d. Overcurrent.
    e. Overvoltage.
    f. Overtemperature.
    g. Excessive voltage total harmonic distortion.
    h. Capacitor overload.
    i. Loss of capacitance.
13. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with electrical power monitoring and control network. Communication module shall have capability to transmit the following data to remote monitoring devices:
    a. System in alarm.
    b. Power factor set point.
    c. Corrected power factor.
    d. Number of capacitor steps activated.

D. Source Quality Control
   1. Factory test power factor correction equipment before shipment. Comply with NEMA CP 1. Include the following:

a. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
b. Functional test of all operations, controls, indicators, sensors, and protective devices.

1.3 EXECUTION

A. Installation
1. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 3.
2. Comply with mounting and anchoring requirements specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
3. Maintain minimum workspace according to manufacturer's written instructions.
4. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.
5. Identify components according to Division 16 Section "Electrical Identification".

B. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Tests and Inspections: Perform each visual and mechanical inspection and electrical test stated in the following Sections, except optional tests, in NETA Acceptance Testing Specification. Certify compliance with test parameters.
a. Current Transformers.
b. Capacitors and Reactors, Capacitors.

C. Startup Service
1. Perform startup service.
a. Complete installation and startup checks according to manufacturer's written instructions.
b. Connect and run installed motors and equipment to verify the automatic switching of the capacitors. Verification shall include automatic switching of the total capacity of installed capacitors.
1) Provide sufficient inductive/reactive load banks, in combination with resistive load banks, for the test.

D. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units.

END OF SECTION 16920

SECTION 16920a - MOTOR-CONTROL CENTERS

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for motor-control centers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary

1. Section includes MCCs for use with ac circuits rated 600 V and less and having the following factory-installed components:
   a. Incoming main lugs and OCPDs.
   b. Full-voltage magnetic controllers.
   c. Reduced-voltage magnetic controllers.
   d. Reduced-voltage, solid-state controllers.
   e. Multispeed controllers.
   f. VFCs.
   g. Feeder-tap units.
   h. TVSS.
   i. Instrumentation.
   j. Auxiliary devices.

C. Definitions

1. BAS: Building automation system.
2. CE: Conformite Europeene (European Compliance).
3. CPT: Control power transformer.
4. EMI: Electromagnetic interference.
5. GFCI: Ground fault circuit interrupting.
6. IGBT: Insulated-gate bipolar transistor.
7. LAN: Local area network.
8. LED: Light-emitting diode.
9. MCC: Motor-control center.
10. MCCB: Molded-case circuit breaker.
11. MCP: Motor-circuit protector.
12. NC: Normally closed.
13. NO: Normally open.
14. OCPD: Overcurrent protective device.
15. PCC: Point of common coupling.
16. PID: Control action, proportional plus integral plus derivative.
17. PT: Potential transformer.
18. PWM: Pulse-width modulated.
19. RFI: Radio-frequency interference.
20. SCR: Silicon-controlled rectifier.
21. TDD: Total demand (harmonic current) distortion.
22. THD(V): Total harmonic voltage demand.
23. TVSS: Transient voltage surge suppressor.
24. VFC: Variable-frequency controller.

D. Performance Requirements

1. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals
1. Product Data: For each type of controller and each type of MCC. Include shipping and operating weights, features, performance, electrical ratings, operating characteristics, and furnished specialties and accessories.
2. LEED Submittals:
   a. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.
3. Shop Drawings: For each MCC, manufacturer's approval, custom and production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
   a. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      1) Each installed unit's type and details.
      2) Factory-installed devices.
      3) Enclosure types and details.
      4) Nameplate legends.
      5) Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
      6) Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
      7) Specified optional features and accessories.
   b. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
   c. Nameplate legends.
   d. Vertical and horizontal bus capacities.
   e. Features, characteristics, ratings, and factory settings of each installed unit.
4. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC **OR** at the defined PCC, **as directed**, to specified levels.
5. Standard Drawings: For each MCC, as defined in UL 845.
6. Production Drawings: For each MCC, as defined in UL 845.
7. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
8. Seismic Qualification Certificates: For MCCs, accessories, and components, from manufacturer.
   a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
9. Qualification Data: For qualified testing agency.
10. Product Certificates: For each MCC, from manufacturer.
11. Source quality-control reports.
12. Field quality-control reports.
13. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. Include the following:

a. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.
b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
c. Manufacturer's written instructions for setting field-adjustable overload relays.
d. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
e. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
f. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

14. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
15. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.
16. Warranty: Sample of special warranty.

F. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
   a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Comply with NFPA 70.
5. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

G. Delivery, Storage, And Handling
1. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.
2. Handle MCCs according to the following:
   a. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."
   b. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."
3. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; install temporary electric heating, with at least 250 W per vertical section **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.

H. Project Conditions
1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   a. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
   b. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
   c. Humidity: Less than 95 percent (noncondensing).
   d. Altitude: Exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.
2. Interruption of Existing Electrical Service or Distribution Systems: Do not interrupt electrical service to, or distribution systems within, a facility occupied by Owner or others unless permitted

under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
   a. Notify Owner no fewer than two days in advance of proposed interruption of electrical service.
   b. Indicate method of providing temporary electrical service.
   c. Do not proceed with interruption of electrical service without Owner's written permission.
   d. Comply with NFPA 70E.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for MCCs, including clearances between MCCs and adjacent surfaces and other items.

I. Coordination
1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
2. Coordinate features of MCCs, installed units, and accessory devices with remote pilot devices and control circuits to which they connect.
3. Coordinate features, accessories, and functions of each MCC, each controller, and each installed unit with ratings and characteristics of supply circuits, motors, required control sequences, and duty cycle of motors and loads.

J. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace TVSS **OR** VFCs, **as directed**, that fail in materials or workmanship within specified warranty period.
   a. Warranty Period: Five years from date of Substantial Completion.

1.2 PRODUCTS

A. Manufactured Units
1. General Requirements for MCCs: Comply with NEMA ICS 18 and UL 845, **as directed**.

B. Functional Features
1. Description: Modular arrangement of main units, controller units, control devices, feeder-tap units, instruments, metering, auxiliary devices, and other items mounted in vertical sections of MCC.
2. Controller Units: Combination controller units.
   a. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
   b. Equip units in Type B and Type C MCCs with pull-apart terminal strips for external control connections.
3. Feeder-Tap Units: Through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
4. Future Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.
5. Spare Units: Installed in compartments indicated "spare."

C. Incoming Mains
1. Incoming Mains Location: Top and bottom, **as directed**.
2. Main Lugs Only: Conductor connectors suitable for use with conductor material and sizes.
   a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.
   b. Main and Neutral Lugs: Compression **OR** Mechanical, **as directed**, type.
3. MCCB: Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.

a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   1) Instantaneous trip.
   2) Long- and short-time pickup levels.
   3) Long- and short-time time adjustments.
   4) Ground-fault pickup level, time delay, and I^2t response.
d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
f. MCCB Features and Accessories:
   1) Standard frame sizes, trip ratings, and number of poles.
   2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.
   3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
   7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
   8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
   9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

4. Insulated-Case Circuit Breaker: 80 **OR** 100, **as directed**, percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
   a. Fixed **OR** Drawout, **as directed**, circuit-breaker mounting.
   b. Two-step, stored-energy closing.
   c. Standard **OR** Full, **as directed**,-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
      1) Instantaneous trip.
      2) Long- and short-time time adjustments.
      3) Ground-fault pickup level, time delay, and I^2t response.
   d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   e. Remote trip indication and control.
   f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."

g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
h. Control Voltage: 40-V dc **OR** 125-V dc **OR** 250-V dc **OR** 120-V ac, **as directed**.

D. Combination Controllers
1. Full-Voltage Controllers:
a. General Requirements for Full-Voltage Enclosed Controllers: Comply with NEMA ICS 2, general purpose, Class A.
b. Magnetic Controllers: Full voltage, across the line, electrically held.
1) Configuration: Nonreversing and reversing.
2. Reduced-Voltage Magnetic Controllers:
a. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed transition; adjustable time delay on transition.
b. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
1) Configuration:
a) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
b) Part-Winding Controller: Separate START and RUN contactors, field-selectable for one-half or two-thirds winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
c) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
3. Reduced-Voltage, Solid-State Controllers:
a. General Requirements for Reduced-Voltage, Solid-State Controllers: Comply with UL 508.
b. Reduced-Voltage, Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium-induction motors.
1) Configuration: Standard duty **OR** Severe duty, **as directed**; nonreversible **OR** reversible, **as directed**.
2) Starting Mode: Voltage ramping **OR** Current limit **OR** Torque control **OR** Torque control with voltage boost, **as directed**; field selectable, **as directed**.
3) Stopping Mode: Coast to stop **OR** Adjustable torque deceleration **OR** Adjustable braking, **as directed**; field selectable, **as directed**.
4) Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
5) Shorting and Input Isolation, **as directed**, Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors, **as directed**.
6) Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
7) Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
8) SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with **OR** without, **as directed**, external feedback from the motor or driven equipment.
9) Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
a) Adjusting motor full-load amperes, as a percentage of the controller's rating.

b) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
c) Adjusting linear acceleration and deceleration ramps, in seconds.
d) Initial torque, as a percentage of the nominal motor torque.
e) Adjusting torque limit, as a percentage of the nominal motor torque.
f) Adjusting maximum start time, in seconds.
g) Adjusting voltage boost, as a percentage of the nominal supply voltage.
h) Selecting stopping mode, and adjusting parameters.
i) Selecting motor thermal-overload protection class between 5 and 30.
j) Activating and de-activating protection modes.
k) Selecting or activating communications modes.

10) Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
a) Controller Condition: Ready, starting, running, stopping.
b) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
c) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.

11) Controller Diagnostics and Protection:
a) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
b) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
c) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.
OR
Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.

12) Remote Output Features:
a) All outputs prewired to terminal blocks.
b) Form C status contacts that change state when controller is running.
c) Form C alarm contacts that change state when a fault condition occurs.

13) Optional Features:
a) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc **OR** 4 to 20-mA dc, **as directed**.
b) Additional field-assignable Form C contacts for alarm outputs.
c) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
d) Full-voltage bypass contactor operating automatically **OR** manually, with NORMAL/BYPASS selector switch, **as directed**. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.

4. Multispeed Magnetic Controllers:
a. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
b. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held. Compelling relay to ensure that motor will start only at low speed.
1) Configuration: Nonreversing **OR** Reversing, **as directed**; consequent pole **OR** two winding, **as directed**.
2) Compelling relays shall ensure that motor starts only at low speed.
3) Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.

4) Decelerating timer relays shall ensure automatically timed deceleration through each speed.
5) Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.

5. Disconnecting Means and OCPDs:
   a. Fusible Disconnecting Means:
      1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class L, **as directed**, fuses.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      3) Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
   b. MCP Disconnecting Means:
      1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
      4) NC **OR** NO, **as directed**, alarm contact that operates only when MCP has tripped.
      5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
   c. MCCB Disconnecting Means:
      1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
      2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
      3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
      5) NC **OR** NO, **as directed**, alarm contact that operates only when MCCB has tripped.
   d. Molded-Case Switch Disconnecting Means:
      1) UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
      2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
      3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
      4) NC **OR** NO, **as directed**, alarm contact that operates only when molded-case switch has tripped.
6. Overload Relays:
   a. Melting-Alloy Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   b. Bimetallic Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      4) Ambient compensated.
      5) Automatic resetting.
   c. Solid-State Overload Relays:
      1) Switch or dial selectable for motor running overload protection.

2) Sensors in each phase.
3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
a) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
b) Analog communication module.

d. NC **OR** NO, **as directed**, isolated overload alarm contact.
e. External overload reset push button.

7. Control Power:
a. Control Circuits: 24 **OR** 120, **as directed**,-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.

E. VFCS
1. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C, **as directed**.
2. Application: Constant torque and variable torque, **as directed**.
3. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
a. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
b. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
c. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
d. Listed and labeled for single-phase use by an NRTL acceptable to authorities having jurisdiction.
4. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
5. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes, **as directed**; maximum voltage equals input voltage.
6. Unit Operating Requirements:
a. Input AC Voltage Tolerance: Plus 10 and minus 10 **OR** 15, **as directed**, percent of VFC input voltage rating.
b. Input AC Voltage Unbalance: Not exceeding 3 **OR** 5, **as directed**, percent.
c. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
d. Minimum Efficiency: 96 **OR** 97, **as directed**, percent at 60 Hz, full load.
e. Minimum Displacement Primary-Side Power Factor: 96 **OR** 98, **as directed**, percent under any load or speed condition.
f. Overload Capability: 1.1 **OR** 1.5, **as directed**, times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
g. Starting Torque: Minimum of 100 percent of rated torque from 3 to 60 Hz.
h. Speed Regulation: Plus or minus 5 **OR** 10, **as directed**, percent.
i. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
j. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
7. Inverter Logic: Microprocessor based, 16 **OR** 32, **as directed**, bit, isolated from all power circuits.

8. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
   a. Signal: Electrical.
      OR
      Signal: Pneumatic.
9. Internal Adjustability Capabilities:
   a. Minimum Speed: 5 to 25 percent of maximum rpm.
   b. Maximum Speed: 80 to 100 percent of maximum rpm.
   c. Acceleration: 0.1 to 999.9 seconds.
   d. Deceleration: 0.1 to 999.9 seconds.
   e. Current Limit: 30 to a minimum of 150 percent of maximum rating.
10. Self-Protection and Reliability Features:
   a. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
   b. Loss of Input Signal Protection: Selectable response strategy including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
   c. Under- and overvoltage trips.
   d. Inverter overcurrent trips.
   e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
   f. Critical frequency rejection, with three selectable, adjustable deadbands.
   g. Instantaneous line-to-line and line-to-ground overcurrent trips.
   h. Loss-of-phase protection.
   i. Reverse-phase protection.
   j. Short-circuit protection.
   k. Motor overtemperature fault.
11. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
12. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
13. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
14. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
15. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
16. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch, with power fuse block and current-limiting fuses **OR** NEMA AB 1, thermal-magnetic circuit breaker **OR** NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses **OR** NEMA KS 1, fusible switch, **as directed**, with pad-lockable, door-mounted handle mechanism.
   a. Disconnect Rating (for VFCs without bypass systems): Not less than 115 percent of VFC input current rating.
   b. Disconnect Rating (for VFCs with bypass systems): Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
   c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
   d. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
   e. NC **OR** NO, **as directed**, alarm contact that operates only when circuit breaker has tripped.

F. VFC Controls And Indication
1. Status Lights: Door-mounted LED indicators displaying the following conditions:
   a. Power on.
   b. Run.
   c. Overvoltage.
   d. Line fault.
   e. Overcurrent.
   f. External fault.
2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
   a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
   b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      1) Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
3. Historical Logging Information and Displays:
   a. Running log of total power versus time.
   b. Total run time.
   c. Fault log, maintaining last four faults with time and date stamp for each.
4. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters, including, but not limited to:
   a. Output frequency (Hz).
   b. Motor speed (rpm).
   c. Motor status (running, stop, fault).
   d. Motor current (amperes).
   e. Motor torque (percent).
   f. Fault or alarming status (code).
   g. PID feedback signal (percent).
   h. DC-link voltage (V dc).
   i. Set point frequency (Hz).
   j. Motor output voltage (V ac).
5. Control Signal Interfaces:
   a. Electric Input Signal Interface:
      1) A minimum of two programmable analog inputs: 0- to 10-V dc **OR** 4- to 20-mA dc **OR** Operator-selectable "x"- to "y"-mA dc, **as directed**.
      2) A minimum of six multifunction programmable digital inputs.
   b. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).
   c. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
      1) 0- to 10-V dc.
      2) 4- to 20-mA dc.
      3) Potentiometer using up/down digital inputs.
      4) Fixed frequencies using digital inputs.
   d. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc **OR** 4- to 20-mA dc **OR** operator-selectable "x"- to "y"-mA dc, **as directed**), which can be configured for any of the following:
      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (V dc).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set point frequency (Hz).

e. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   1) Motor running.
   2) Set point speed reached.
   3) Fault and warning indication (overtemperature or overcurrent).
   4) PID high- or low-speed limits reached.

6. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
   a. Number of Loops: One **OR** Two, **as directed**.
7. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage, **as directed**. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
   a. Network Communications Ports: Ethernet and RS-422/485.
   b. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet **OR** Echelon LonWorks **OR** Ethernet TCP/IP **OR** Johnson Metasys N2 **OR** Modbus/Memobus **OR** Siemens System 600 APOGEE, **as directed**; protocols accessible via the communications ports.

G. VFC Line Conditioning And Filtering
1. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at input terminals of VFCs to less than 5 **OR** 8, **as directed**, percent and THD(V) to 3 **OR** 5, **as directed**, percent.
2. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD and THD(V) at the defined PCC per IEEE 519.
3. Input Line Conditioning: <**Insert requirements**>.
4. VFC Output Filtering: <**Insert requirements**>.
5. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

H. VFC Bypass Systems
1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes, and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
2. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.

   OR

   Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
3. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode, **as directed**.
   a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**,-rated contactor.
   b. Output Isolating Contactor: Non-load-break, IEC **OR** NEMA, **as directed**,-rated contactor.
   c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

   OR

   Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier, **as directed**, arranged to isolate

the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**,-rated contactor.
b. Input and Output Isolating Contactors: Non-load-break, IEC **OR** NEMA, **as directed**,-rated contactors.
c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

4. Bypass Contactor Configuration: Full-voltage (across-the-line) **OR** Reduced-voltage (autotransformer), **as directed**, type.
   a. NORMAL/BYPASS selector switch.
   b. HAND/OFF/AUTO selector switch.
   c. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
   d. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
      1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
      2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
   e. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
   f. CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
5. Overload Relays: NEMA ICS 2.
   a. Melting-Alloy Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
   b. Bimetallic Overload Relays:
      1) Inverse-time-current characteristic.
      2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      4) Ambient compensated.
      5) Automatic resetting.
   c. Solid-State Overload Relays:
      1) Switch or dial selectable for motor-running overload protection.
      2) Sensors in each phase.
      3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      5) Analog communication module.
      6) NC **OR** NO, **as directed**, isolated overload alarm contact.
      7) External overload reset push button.

I. Optional VFC Features
   1. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications, when overload protection activates.
      a. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.

b. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
c. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

2. Damper control circuit with end of travel feedback capability.
3. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
4. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
5. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station **OR** smoke-control fan controller, **as directed**, this password-protected input:
   a. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
   b. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
      OR
      Forces VFC to transfer to Bypass Mode and operate motor at full speed.
   c. Causes display of Override Mode on the VFC display.
   d. Reset VFC to normal operation on removal of override signal automatically **OR** manually, **as directed**.
6. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
7. Remote digital operator kit.
8. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

J. Feeder-Tap Units
1. MCCB: Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
   a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
   b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
   c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long- and short-time time adjustments.
      4) Ground-fault pickup level, time delay, and I^2t response.
   d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
   e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
   f. MCCB Features and Accessories:
      1) Standard frame sizes, trip ratings, and number of poles.
      2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.
      3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring And Control".
7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate specified fuses with lockable handle.
3. Fuses are specified in Division 16 Section "Fuses".

K. Transient Voltage Suppression Devices

1. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in **OR** plug-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the MCC short-circuit rating, and with the following features and accessories:
   a. Fuses, rated at 200-kA interrupting capacity.
   b. Fabrication using bolted compression lugs for internal wiring.
   c. Integral disconnect switch.
   d. Redundant suppression circuits.
   e. Redundant replaceable modules.
   f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
   g. LED indicator lights for power and protection status.
   h. Audible alarm, with silencing switch, to indicate when protection has failed.
   i. Form-C contacts rated at 5 A and 250-V ac, one NO and one NC, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
   j. Four **OR** Six, **as directed**,-digit, transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**,-V, three-phase, four-wire circuits shall be as follows:
   a. Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
   b. Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
   c. Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.

   OR

   Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

a. Line to Neutral: 400 V, 800 V from high leg.
b. Line to Ground: 400 V.
c. Neutral to Ground: 400 V.

OR

Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

L. Instrumentation

1. Instrument Transformers (for Owner metering): IEEE C57.13, NEMA EI 21.1, and the following:
   a. PTs: IEEE C57.13; 120 V, 60 Hz, single **OR** tapped **OR** double, **as directed**, secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
   b. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound **OR** bushing **OR** bar or window, **as directed**, type; single **OR** double, **as directed**, secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
   c. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
   d. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   a. Listed or recognized by a nationally recognized testing laboratory.
   b. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
   c. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:
      1) Phase Currents, Each Phase: Plus or minus 1 percent.
      2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
      3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
      4) Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
      5) Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
      6) Power Factor: Plus or minus 2 percent.
      7) Frequency: Plus or minus 0.5 percent.
      8) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
      9) Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
      10) Contact devices to operate remote impulse-totalizing demand meter.
   d. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
   a. Meters: 4-inch (100-mm) diameter or 6 inches (150 mm) square, flush or semiflush, with antiparallax 250-degree scale and external zero adjustment.
   b. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
4. Instrument Switches: Rotary type with off position.
   a. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.
   b. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.

5. Feeder Ammeters: 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for feeder circuits, unless otherwise indicated.
6. Watt-Hour Meters and Wattmeters:
   a. Comply with ANSI C12.1.
   b. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
   c. Suitable for connection to three- and four-wire circuits.
   d. Potential indicating lamps.
   e. Adjustments for light and full load, phase balance, and power factor.
   f. Four-dial clock register.
   g. Integral demand indicator.
      OR
      Contact devices to operate remote impulse-totalizing demand meter.
   h. Ratchets to prevent reverse rotation.
   i. Removable meter with drawout test plug.
   j. Semiflush mounted case with matching cover.
   k. Appropriate multiplier tag.
7. Impulse-Totalizing Demand Meter:
   a. Comply with ANSI C12.1.
   b. Suitable for use with MCC watt-hour meter, including two-circuit totalizing relay.
   c. Cyclometer.
   d. Four-dial, totalizing kilowatt-hour register.
   e. Positive chart drive mechanism.
   f. Capillary pen holding a minimum of one month's ink supply.
   g. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
   h. Capable of indicating and recording five **OR** 15 **OR** 30, **as directed**,-minute integrated demand of totalized system.

M. MCC Control Power
1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from CPT.
   OR
   Control Circuits: 120-V ac, supplied from remote branch circuit.
2. Electrically Interlocked Main and Tie Circuit Breakers: Two CPTs in separate compartments, with interlocking relays, connected to the primary side of each CPT at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
3. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

N. Enclosures
1. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 1 **OR** Type 1A **OR** Type 2 **OR** Type 12, **as directed**, unless otherwise indicated to comply with environmental conditions at installed location.
2. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
   a. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point **OR** Manual switching of branch-circuit protective device, **as directed**.
   b. Space-Heater Power Source: Transformer, factory installed in MCC **OR** 120-V external branch circuit, **as directed**.
3. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray **OR** custom color, **as directed**, finish over a rust-inhibiting primer on treated metal surface.

4. Outdoor Enclosures: Type 3R, non-walk-in aisle **OR** Type 3R, with interior-lighted walk-in aisle, **as directed**.
   a. Finish: Factory-applied finish in manufacturer's standard **OR** custom, **as directed**, color; undersurfaces treated with corrosion-resistant undercoating.
   b. Enclosure: Flat **OR** Downward, rearward sloping, **as directed**, roof; bolt-on rear covers **OR** rear hinged doors, **as directed**, for each section, with provisions for padlocking.
   c. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking **OR** cylinder lock, **as directed**.
   d. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; GFCI duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
   e. Walk-in Aisle Heating and Ventilating:
      1) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 104 deg F (40 deg C).
      2) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 23 deg F (minus 5 deg C).
      3) Ventilating openings complete with replaceable fiberglass air filters, **as directed**.
      4) Thermostat: Single stage; wired to control heat and exhaust fan.
   f. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a CPT within the switchboard. Supply voltage shall be 120 **OR** 120/240 **OR** 120/208, **as directed**,-V ac.
      OR
      Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
5. Compartments: Modular; individual lift-off, **as directed**, doors with concealed hinges and quick-captive screw fasteners. Interlocks on units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
6. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
7. Wiring Spaces:
   a. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
   b. Horizontal wireways in bottom **OR** top **OR** bottom and top, **as directed**, of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.

O. Auxiliary Devices
1. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
   a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**,-duty, oiltight, **as directed**, type.
      1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**, contact unless otherwise indicated.
      2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; <**Insert color(s)**>; push to test, **as directed**.
      3) Selector Switches: Rotary type.
   b. Elapsed-Time Meters: Heavy duty with digital readout in hours; nonresettable **OR** resettable, **as directed**.
   c. Meters: Panel type, 2-1/2-inch (64-mm) minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy with selector switches having an off position.
2. NC **OR** NO **OR** Reversible NC/NO, **as directed**, contactor auxiliary contact(s).

3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
5. Space heaters, with NC auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
6. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
7. Cover gaskets for Type 1 enclosures.
8. Terminals for connecting power factor correction capacitors to the line **OR** load, **as directed**, side of overload relays.
9. Spare control-wiring terminal blocks; unwired **OR** wired, **as directed**.
10. Spare-Fuse Cabinet: Identified and compartmented steel box **OR** cabinet with hinged lockable door, **as directed**.

P. Characteristics And Ratings
1. Wiring: NEMA ICS 18, Class I **OR** Class I-S, **as directed**, Type A **OR** Type B, for starters above Size 3 **OR** Type B-D, for starter Size 3 and below **OR** Type B-T, for starter Size 3 and below **OR** Type C, **as directed**.
   OR
   Wiring: NEMA ICS 18, Class II **OR** Class II-S, **as directed**, Type B, for starters above Size 3 **OR** Type B-D, for starter Size 3 and below **OR** Type B-T, for starter Size 3 and below **OR** Type C, **as directed**.
2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
3. Nominal System Voltage: 480 V, three phase, three wire **OR** 480Y/277 V, three phase, four wire, **as directed**.
   OR
   Nominal System Voltage: 208 V, three phase, three wire **OR** 208/120 V, three phase, four wire, **as directed**.
4. Short-Circuit Current Rating for Each Unit: Combination series rated **OR** Fully rated, **as directed**; 22 **OR** 42 **OR** 65 **OR** 100, **as directed**, kA.
5. Short-Circuit Current Rating of MCC: Combination series rated **OR** Fully rated, **as directed**, with its main overcurrent device; 22 **OR** 42 **OR** 65 **OR** 100, **as directed**, kA.
6. Environmental Ratings:
   a. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
   b. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
   c. Humidity Rating: Less than 95 percent (noncondensing).
   d. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.
7. Main-Bus Continuous Rating: 600 **OR** 800 **OR** 1000 **OR** 1200 **OR** 1600 **OR** 2000, **as directed**, A.
8. Vertical-Bus Minimum, **as directed**, Continuous Rating: 300 **OR** 600 **OR** 1200, **as directed**, A.
9. Horizontal and Vertical Bus Bracing (Short-Circuit Current Rating): Match MCC short-circuit current rating.
10. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends, **as directed**. Brace bus extensions for busway feeder bus, **as directed**.
11. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.

12. Phase- and Neutral-, **as directed**,Bus Material: Hard-drawn copper of 98 percent conductivity, silver **OR** tin, **as directed**, plated.
    OR
    Phase- and Neutral-, **as directed**,Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy.
13. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus, **as directed**.
    OR
    Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus, **as directed**.
14. Ground Bus: Minimum size required by UL 845, hard-drawn copper of 98 percent conductivity, equipped with mechanical **OR** compression, **as directed**, connectors for feeder and branch-circuit equipment grounding conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run, **as directed**.
15. Front-Connected, Front-Accessible MCCs:
    a. Main Devices: Drawout **OR** Fixed, **as directed**, mounted.
    b. Controller Units: Drawout and fixed, **as directed**, mounted.
    c. Feeder-Tap Units: Drawout and fixed, **as directed**, mounted.
    d. Sections front and rear aligned.
16. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic MCC. Provide service entrance label and necessary applicable service entrance features.
17. Owner Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks, **as directed**.
18. Bus Transition and Incoming Pull Sections: Matched and aligned with basic MCC.
19. Pull Box on Top of an MCC:
    a. Adequate ventilation to maintain temperature in pull box within same limits as MCC.
    b. Set back from front to clear circuit-breaker removal mechanism.
    c. Removable covers forming top, front, and sides. Top covers at rear easily removable for drilling and cutting.
    d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
    e. Cable supports arranged to facilitate cabling and adequate to support cables, including those for future installation.
    f. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
20. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of unit.
21. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
22. Fungus Proofing: Permanent fungicidal treatment for OCPDs and other components including instruments and instrument transformers.

Q. Source Quality Control
1. MCC Testing: Inspect and test MCCs according to requirements in NEMA ICS 18.
2. VFC Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
    a. Test each VFC while connected to its specified motor **OR** a motor that is comparable to that for which the VFC is rated, **as directed**.

b. Verification of Performance: Rate VFCs according to operation of functions and features specified.

3. MCCs will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

1.3 EXECUTION

A. Examination
1. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
2. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Harmonic Analysis Study
1. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.
2. Prepare a harmonic analysis study report complying with IEEE 399 and NETA Acceptance Testing Specification.

C. Installation
1. Coordinate layout and installation of MCCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Floor-Mounting Controllers: Install MCCs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
   a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
   b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in each fusible switch.
6. Install fuses in control circuits if not factory installed. Comply with requirements in Division 16 Section "Fuses".
7. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
8. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
9. Install power factor correction capacitors. Connect to the line **OR** load, **as directed**, side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
10. Comply with NECA 1.

D. Identification
1. Comply with requirements in Division 16 Section "Electrical Identification" for identification of MCC, MCC components, and control wiring.

a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
b. Label MCC and each cubicle with engraved nameplate.
c. Label each enclosure-mounted control and pilot device.
d. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.

2. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of MCCs.

E. Control Wiring Installation

1. Install wiring between enclosed controllers **OR** master terminal boards, **as directed**, and remote devices and facility's BAS **OR** and facility's central-control system, **as directed**. Comply with requirements in Division 16 Section "Control-voltage Electrical Power Cables".
2. Bundle, train, and support wiring in enclosures.
3. Connect selector switches and other automatic-control selection devices where applicable.
   a. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
   b. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

F. Connections

1. Comply with requirements for installation of conduit in Division 16 Section "Raceways And Boxes". Drawings indicate general arrangement of conduit, fittings, and specialties.
2. Comply with requirements in Division 16 Section "Grounding And Bonding".

G. Field Quality Control

1. Perform tests and inspections.
2. Acceptance Testing Preparation:
   a. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
   b. Test continuity of each circuit.
3. Tests and Inspections:
   a. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   b. Test insulation resistance for each enclosed controller element, component, connecting motor supply, feeder, and control circuits.
   c. Test continuity of each circuit.
   d. Verify that voltages at controller locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
   e. Test each motor for proper phase rotation.
   f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
      1) Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
      2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Substantial Completion.

3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

j. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.

4. Enclosed controllers will be considered defective if they do not pass tests and inspections.

5. Prepare test and inspection reports, including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

H. Startup Service

1. Perform startup service.

a. Complete installation and startup checks according to manufacturer's written instructions.

I. Adjusting

1. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

2. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.

3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

4. Set the taps on reduced-voltage autotransformer controllers at 50 **OR** 65 **OR** 80, **as directed**, percent.

5. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.

6. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

7. Set field-adjustable circuit-breaker trip ranges as specified in Division 16 Section "Overcurrent Protective Device Coordination".

J. Protection

1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

2. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

K. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controllers, **as directed**.

END OF SECTION 16920a

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Task	Specification	Specification Description
16921	16920a	Motor-Control Centers
16922	16480	Power Distribution Units
16923	01352	No Specification Required
16923	15910a	Enclosed Controllers
16923	16320	Switchgear
16923	16920a	Motor-Control Centers

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SECTION 16930 - LIGHTING CONTROLS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for lighting controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes manually operated lighting controls with relays, electrically operated circuit breakers, and control module.
2. This Section includes manually operated, PC-based, digital lighting controls with external signal source, relays, electrically operated circuit breakers, and control module.
3. This Section includes individually addressable lighting control devices communicating with data-entry and -retrieval devices using DALI protocol.

C. Definitions
1. BACnet: A networking communication protocol that complies with ASHRAE 135.
2. BAS: Building automation system.
3. DALI: Digital addressable lighting interface.
4. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
5. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
6. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
7. PC: Personal computer; sometimes plural as "PCs."
8. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.
9. RS-485: A serial network protocol, similar to RS-232, complying with TIA/EIA-485-A.

D. Submittals
1. Product Data: For control modules, power distribution components, DALI network materials, manual switches and plates, and conductors and cables.
2. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on this Project.
   a. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
   b. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
   c. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
3. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
   a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
   b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

4. Software and Firmware Operational Documentation:
   a. Software operating and upgrade manuals.
   b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
   c. Device address list.
   d. Printout of software application and graphic screens.
5. Field quality-control test reports.
6. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
7. Operation and maintenance data.
8. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
4. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
5. Comply with NFPA 70.

F. Coordination
1. Coordinate lighting control components to form an integrated interconnection of compatible components. Match components and interconnections for optimum performance of lighting control functions.
   a. Coordinate lighting controls with BAS **OR** HVAC controls, **as directed**. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
   b. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
2. Coordinate lighting control components specified in this Section with components specified in Division 16 Section "Panelboards".

G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
   a. Failures include, but are not limited to, the following:
      1) Failure of software input/output to execute switching or dimming commands.
      2) Failure of modular relays to operate under manual or software commands.
      3) Damage of electronic components due to transient voltage surges.
   b. Warranty Period: Two years from date of Substantial Completion.
   c. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.
   d. Extended Warranty Period for Electrically Held Relays: 10 years from date of Substantial Completion.

H. Software Service Agreement (May Not Be Allowed For Publicly Funded Projects)
1. Technical Support: Beginning with Substantial Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revise licenses for use of the software.

a. Provide 30-day notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment, if necessary.

1.2 PRODUCTS

A. System Requirements

1. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.
2. Performance Requirements (for programmable system that controls manual and automatic operation that is not PC based): Manual switch operation sends a signal to programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays **OR** electrically operated circuit breakers, **as directed**, in the power-supply circuits to groups of lighting fixtures or other loads.
3. Performance Requirements (for PC-based programmable system that controls manual and automatic operation): Manual switches, an internal timing and control unit, and external sensors or other control signal sources send a signal to a PC-based programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays **OR** electrically operated circuit breakers, **as directed**, in the power-supply circuits, or routes variable commands to one or more dimmers, for groups of lighting fixtures or other loads.
4. Performance Requirements (for DALI-compliant program): Individually addressable devices (such as electronic ballasts, dimmers, and manual switches) are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs). Devices also report status to data-entry and -retrieval devices though the bus.
5. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.
   a. Hardwired Points:
      1) Monitoring: On-off status, <**Insert monitoring point**>.
      2) Control: On-off operation, <**Insert control point**>.
   b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor lighting from a BAS operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the BAS.

B. Control Module

1. Control Module Description: (This is a generic, nonproprietary control module that is not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral alphanumeric LCD or LED shall display menu-assisted programming and control.
2. Control Module Description: (These are typical systems developed by time-switch manufacturers as an expansion and refinement of their microprocessor-based, digital, time-switch product lines - controls are not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Unit shall be programmable for control of indicated number of output circuits. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices, all located in other enclosures. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral

alphanumeric LCD shall display manual-control and programming steps. Modules and their associated control panels shall include the following features:

a. Multichannel output with <**Insert number**> channels.

OR

Multiple inputs and multichannel output arranged for <**Insert number**> channels.

b. Multiple inputs for indicated occupancy sensors and hand-held programming device.

3. Control Module Description: (These are low-voltage control systems developed by high-end, remote-control dimmer system manufacturers - controls are not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Control units shall be programmable and capable of receiving inputs from indicated sensors and hand-held programmer. Output circuits shall be pilot-duty relays compatible with power switching devices. Output circuits shall include digital circuits arranged to transmit control commands to remote preset dimmers. Modules and their associated control panels shall include the following features:

a. Multichannel output with <**Insert number**> channels.

OR

Multiple inputs and multichannel output arranged for <**Insert number**> channels.

b. Multiple inputs for occupancy sensors, daylight sensors, and dimming systems with associated daylight sensors.

4. Control Module Description: (This is a low-voltage control system developed around panelboards with electrically operated, molded-case circuit breakers and control module installed in panelboard - controls are not PC based.) Panelboard mounted; comply with UL 916 (CSA C22.2, No. 205); microprocessor based, solid-state, 365-day timing and control unit. Control units shall be programmable and capable of receiving inputs from sensors and other sources. Panelboard shall use low-voltage-controlled, electrically operated, molded-case branch circuit breakers as prime power-circuit switching devices. Circuit breakers and a limited number of digital or analog, low-voltage control-circuit outputs shall be individually controlled by control module. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable. Panelboard shall also comply with Division 16 Section "Panelboards".

5. Control Module Description: (This is a refinement of classic low-voltage control system originally developed for manual, multipoint lighting control using latching-type, single-pole relays to switch 120- and 277-V circuits - controls are not PC based.) Comply with UL 508 (CSA C22.2, No. 14); microprocessor-based, programmable, control unit; mounted in preassembled, modular relay panel. Low-voltage-controlled, latching-type, single-pole lighting circuit relays shall be prime output circuit devices. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays. Control units shall be capable of receiving inputs from sensors and other sources. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable.

6. Control Module Description: (This is a typical PC-based software control system developed to operate panelboards with electrically operated circuit breakers, relay boards with latching-type control relays, and individually addressable DALI-compliant devices. This control scheme is also suitable for integrating one or more of these boards to a PC-based control network (such as BAS, detention monitoring and control system, and HVAC control system) specified in another Section.) Programmable, PC-based unit with 17-inch color video monitor **OR** 15-inch color LCD, **as directed**, and keyboard for graphic display and programming of system status and to override breaker status; and to display status of local override controls and diagnostic information. If the control module is applied to emergency lighting units, control unit shall indicate failure of normal power and that the lighting units are, or are not, powered by the alternate power source.

a. Display: Single graphic display for programming lighting control panelboards.

OR

Display: Separate graphic displays for programming each lighting control panelboard.

b. Interoperability: Control module shall be configured to connect with other control systems using RS-485 network to enable remote workstations to use control module functions.

OR

Interoperability: Control module shall be configured to connect to LonWorks-compliant **OR** BACnet-compliant, **as directed**, network, resulting in extending control to any network-compliant devices such as occupancy switches.

OR

Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with their PCs. Software shall be written for Windows operating system, with Web page as the display and ActiveX controls that can be accessed through an Internet browser. Include at least three levels of password protection. Include an egress lighting option that will provide each user with a lighted path for exiting the building after normal working hours.

OR

Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with DALI-compliant, digital-communication devices. Software shall be written for Windows operating system, with the full suite of DALI commands and device parameter settings.

c. System Memory: Nonvolatile. System shall reboot program and reset time automatically without errors after power outages up to 90 days' duration.

d. Software: Lighting control software shall be capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses, and assigning switch input and relay output modes.

e. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight saving time and shall provide weekly routine and annual holiday scheduling.

f. Astronomic Control: Automatic adjustment of dawn and dusk switching.

g. Demand Control: Demand shall be monitored through pulses from a remote meter and shall be controlled by programmed switching of loads. System capability shall include sliding window averaging and programming of load priorities and characteristics. Minimum of two different time-of-day demand schedules shall execute load-management control actions by switching output circuits or by transmitting other types of load-control signals.

h. Confirmation: Each relay or contactor device operated by system shall have auxiliary contacts that provide a confirmation signal to the system of on or off status of device. On or off status confirmation for each electrically operated circuit breaker shall be provided by an auxiliary contact or by a sensing device at load terminal.

1) Software shall interpret status signals, provide for their display, and initiate failure signals.

OR

Lamp or LED at control module or display panel shall identify status of each controlled circuit.

i. Remote Communication Capability: Allow programming, data-gathering interrogation, status display, and controlled command override from a PC at a remote location over telephone lines **OR** data links **OR** DALI networks **OR** power line carrier, **as directed**. System shall include modem, communications and control software, and remote computer compatibility verification for this purpose.

j. Telephone Override Capability: Override programmed lighting shutdown commands by telephoning computer and shall enter a voice-menu-guided, override touch-tone code specific to zone being controlled.

k. Local Override Capability: Manual, low-voltage control devices shall override programmed shutdown of lighting and shall override other programmed control for intervals that may be duration programmed.

l. Automatic Control of Local Override: Automatic control shall switch lighting off if lighting has been switched on by local override. Comply with provisions in California Code of Regulations, Title 24, Part 6, **as directed**.

m. Automatic battery backup shall provide power to maintain program and system clock operation for 90 days' minimum duration when power is off.

n. Programmed time signals shall change preset scenes and dimmer settings.

o. Daylight Balancing Dimming Control: Control module shall interpret variable analog signal from photoelectric sensor and shall route dimming signals to dimming fluorescent ballast control circuits. Signal shall control dimming of fixture so illumination level remains constant as daylight contribution varies.

p. Daylight Compensating Switch Control: Control module shall interpret a preset threshold illumination-level signal from a photoelectric relay and shall activate relays controlling power to selected groups of lighting fixtures to turn them on and off to maintain adjustable minimum illumination level as daylight contribution varies.

q. Energy Conservation: Bilevel control of special ballasts or dimming circuits to comply with local energy codes.

r. Flick Warning: Programmable momentary turnoff of lights shall warn that programmed shutoff will occur after a preset interval. Warning shall be repeated after a second preset interval before end of programmed override period.

s. Diagnostics: When system operates improperly, software shall initiate factory-programmed diagnosis of failure and display messages identifying problem and possible causes.

t. Additional Programming: In addition to system programming by the PC, individual control modules shall be programmable using data-entry and -retrieval (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs).

C. Power Distribution Components (For DALI-Compliant Networks)

1. Modular Relay Panel: Comply with UL 508 (CSA C22.2, No. 14) and UL 916 (CSA C22.2, No. 205); factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.

a. Cabinet: Steel with hinged, locking door.

1) Barriers separate low-voltage and line-voltage components.

2) Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.

3) Control Power Supply: Transformer and full-wave rectifier with filtered dc output.

b. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.

1) Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.

2) Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.

3) Endurance: 50,000 cycles at rated capacity.

4) Mounting: Provision for easy removal and installation in relay cabinet.

2. Electrically Operated, Molded-Case Circuit-Breaker Panelboard: Comply with NEMA PB 1 and UL 50 (CSA C22.2, No. 94), UL 67 (CSA C22.2, No. 29), UL 489 (CSA C22.2, No. 65), and UL 916 (CSA C22.2, No. 205).

a. Cabinets: In addition to requirements specified below, comply with Division 16 Section "Panelboards".

b. Electrically Operated, Molded-Case Circuit Breakers: Bolt-on type.

1) Switching Endurance Ratings: Certified by manufacturer or by a nationally recognized testing laboratory (NRTL) for at least 20,000 open and close operations under rated load at 0.8 power factor.

2) Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent tungsten filament load.

3) Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent fluorescent ballasts rated for 10 percent total harmonic distortion.

4) Listed and labeled as complying with UL SWD, HCAR, and HID ratings by a national recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction.

3. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels.

OR
Line-Voltage Surge Suppression: Field-mounting surge suppressors that comply with Division 16 Section "Transient Voltage Suppression" for Category A locations.
OR
Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels or field-mounting surge suppressors that comply with Division 16 Section "Transient Voltage Suppression" for Category A locations.

D. DALI Network Materials
1. Network Power Supply and Router: Interface device connecting TCP/IP control networks to DALI-compliant network.
   a. DALI-Compliant Network Power Rating: One full-rated network for **OR** Two full-rated networks, each capable of, **as directed**, powering up to 64 addressable devices for each network; suitable for use with NFPA 70, Class 1 and Class 2 control circuits; and 16 V dc, 250 mA.
   b. Primary Power: 120 or 277 V, field selectable; 12 VA.
   c. 10basT Ethernet port.
   d. LED indicator lights for Ethernet status (link, send, and receive), power-on, and DALI network failure.
2. Lighting Control Software:
   a. Five-tier hierarchical architecture; high-speed, parallel query; and distributed-logic processing scalable from single rooms to full campuses.
   b. Automatic backup for all settings and parameters.
   c. TCP/IP network protocol.
   d. Interactive with other building management systems at TCP/IP level.
   e. At least three security levels.
   f. Support the full suite of DALI commands and device parameter settings.
   g. Scheduling modules to provide building-wide scene scheduling.
   h. Billing modules to track energy use for multiple tenants and able to produce monthly billing statements.
   i. Support load shedding, peak shaving, sweeps with local override, and other energy-conservation measures.
   j. Able to report individual device status, including inoperative lamps, ballast failure detection, and dimmer position.

E. Manual Switches And Plates
1. Push-Button Switches: Modular, momentary-contact, low-voltage type.
   a. Match color specified in Division 16 Section "Wiring Devices".
   b. Integral green LED **OR** neon, **as directed**, pilot light to indicate when circuit is on.
   c. Internal white LED **OR** neon, **as directed**, locator light to illuminate when circuit is off.
2. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Division 16 Section "Wiring Devices".
3. Wall-Box Dimmers: Comply with Division 16 Section "Wiring Devices".
4. Wall Plates: Single and multigang plates as specified in Division 16 Section "Wiring Devices"
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

F. Conductors And Cables
1. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 16 Section "Conductors And Cables".
2. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG, complying with Division 16 Section "Conductors And Cables".
3. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG, complying with Division 16 Section "Conductors And Cables".

4. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e **OR** 6, **as directed**, for horizontal copper cable and with Division 16 Section "Conductors And Cables For Electronic Safety And Security".

1.3 EXECUTION

A. Wiring Installation
1. Comply with NECA 1.
2. Wiring Method: Install wiring in raceways except where installed in accessible ceilings and gypsum board partitions. Comply with Division 16 Section "Conductors And Cables". Minimum conduit size shall be 1/2 inch (13 mm).
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
4. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
5. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
7. Identify components and power and control wiring according to Division 16 Section "Electrical Identification".

B. Field Quality Control
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
   a. Test for circuit continuity.
   b. Verify that the control module features are operational.
   c. Check operation of local override controls.
   d. Test system diagnostics by simulating improper operation of several components selected by the Owner.

C. Software Installation
1. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

D. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors and to assist Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems.

END OF SECTION 16930

SECTION 16930a - LIGHTING CONTROL DEVICES

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for lighting control devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following lighting control devices:
a. Time switches.
b. Outdoor and Indoor photoelectric switches.
c. Indoor occupancy sensors.
d. Outdoor motion sensors.
e. Lighting contactors.
f. Emergency shunt relays.

C. Definitions
1. LED: Light-emitting diode.
2. PIR: Passive infrared.

D. Submittals
1. Product Data: For each type of product indicated.
2. Field quality-control test reports.
3. Operation and maintenance data.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.2 PRODUCTS

A. Time Switches
1. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
a. Contact Configuration: SPST **OR** DPST **OR** DPDT, **as directed**.
b. Contact Rating: 30-A inductive or resistive, 240-V ac **OR** 20-A ballast load, 120/240-V ac, **as directed**.
c. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.
OR
Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.
OR
Programs: channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
OR
Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.

OR

Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.

OR

Programs: channels; each channel shall be individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.

OR

Programs: channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.

OR

Program: Configuration, as directed by the Owner and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.

d. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels, **as directed**.

e. Astronomic Time: All **OR** Selected, **as directed**, channels.

f. Battery Backup: For schedules and time clock.

2. Electromechanical-Dial Time Switches: Type complying with UL 917.

a. Contact Configuration: SPST **OR** DPST **OR** SPDT **OR** DPDT, **as directed**.

b. Contact Rating: 30-A inductive or resistive, 240-V ac **OR** 20-A ballast load, 120/240-V ac, **as directed**.

c. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.

d. Astronomic time dial.

e. Eight-Day Program: Uniquely programmable for each weekday and holidays.

f. Skip-a-day mode.

g. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

B. Outdoor Photoelectric Switches

1. Description: Solid state, with SPST **OR** DPST, **as directed**, dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off, **as directed**.

b. Time Delay: 15-second minimum, to prevent false operation.

c. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.

d. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

OR

Description: Solid state, with SPST **OR** DPST, **as directed**, dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.

b. Time Delay: 30-second minimum, to prevent false operation.

c. Lightning Arrester: Air-gap type.

d. Mounting: Twist lock complying with IEEE C136.10, with base.

C. Indoor Photoelectric Switches

1. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit mounted on luminaire, **as directed**, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
   a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   b. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
   c. Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx) **OR** 100 to 1000 fc (1080 to 10 800 lx), **as directed**, with an adjustment for turn-on and turn-off levels within that range.
   d. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
   e. Indicator: Two LEDs to indicate the beginning of on-off cycles.
2. Skylight Photoelectric Sensors: Solid-state, light-level sensor; housed in a threaded, plastic fitting for mounting under skylight, facing up at skylight; with separate relay unit mounted on luminaire, **as directed**, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
   a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   b. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
   c. Light-Level Monitoring Range: 1000 to 10,000 fc (10 800 to 108 000 lx), with an adjustment for turn-on and turn-off levels within that range.
   d. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
   e. Indicator: Two LEDs to indicate the beginning of on-off cycles.

D. Indoor Occupancy Sensors
1. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
   a. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   b. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   c. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
   d. Mounting:
      1) Sensor: Suitable for mounting in any position on a standard outlet box.
      2) Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
      3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   e. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
   f. Bypass Switch: Override the on function in case of sensor failure.
   g. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
2. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
   a. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
   b. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

c. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.

3. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
   a. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
   b. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
   c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
   d. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
   e. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).
4. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
   a. Sensitivity Adjustment: Separate for each sensing technology.
   b. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
   c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

E. Outdoor Motion Sensors (PIR)
1. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as raintight according to UL 773A.
   a. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
   b. Mounting:
      1) Sensor: Suitable for mounting in any position on a standard outdoor junction box.
      2) Relay: Internally mounted in a standard weatherproof electrical enclosure.
      3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
   c. Bypass Switch: Override the on function in case of sensor failure.
   d. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc (11 to 215 lx); keep lighting off during daylight hours.
2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
3. Detection Coverage: Up to 35 feet (11 m), with a field of view of 90 degrees **OR** Up to 100 feet (30 m), with a field of view of 60 degrees **OR** Up to 35 feet (11 m), with a field of view of 180 degrees **OR** Up to 52.5 feet (16 m), with a field of view of 270 degrees, **as directed**.
4. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
5. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
   a. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

b. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

F. Lighting Contactors
1. Description: Electrically operated and mechanically **OR** electrically, **as directed**, held, combination type with fusible switch **OR** nonfused disconnect, **as directed**, complying with NEMA ICS 2 and UL 508.
a. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
b. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
c. Enclosure: Comply with NEMA 250.
d. Provide with control and pilot devices as indicated on Drawings **OR** scheduled, **as directed**, matching the NEMA type specified for the enclosure.
2. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
a. Monitoring: On-off status, as directed by the Owner.
b. Control: On-off operation, as directed by the Owner.

G. Emergency Shunt Relay
1. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic, **as directed**, switching contacts; complying with UL 924.
a. Coil Rating: 120 **OR** 277, **as directed**, V.

H. Conductors And Cables
1. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Conductors And Cables".
2. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 16 Section "Conductors And Cables".
3. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG. Comply with requirements in Division 16 Section "Conductors And Cables".

1.3 EXECUTION

A. Sensor Installation
1. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. Contactor Installation
1. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

C. Wiring Installation
1. Wiring Method: Comply with Division 16 Section "Conductors And Cables". Minimum conduit size shall be 1/2 inch (13 mm).
2. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

D. Identification
   1. Identify components and power and control wiring according to Division 16 Section "Electrical Identification".
      a. Identify controlled circuits in lighting contactors.
      b. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
   2. Label time switches and contactors with a unique designation.

E. Field Quality Control
   1. Perform the following field tests and inspections and prepare test reports:
      a. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
      b. Operational Test: Verify operation of each lighting control device, and adjust time delays.
   2. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 16930a

SECTION 16930b - CENTRAL DIMMING CONTROLS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for central dimming controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes microprocessor-based central dimming controls with the following components:
   a. Control network.
   b. Master-control stations.
   c. Partitioned-space master-control stations.
   d. Wall stations.
   e. Dimmer cabinets.
   f. Manual switches and plates for controlling dimmers.

C. Definitions
1. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.
2. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
3. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.
4. Low Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.
5. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
6. SCR: Silicon-controlled rectifier.
7. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

D. Submittals
1. Product Data: For each type of product indicated.
   a. For central dimming controls; include elevation, features, characteristics, and labels.
   b. For dimmer panels; include dimensions, features, dimmer characteristics, ratings, and directories.
   c. Device plates, plate color, and material.
   d. Ballasts and lamp combinations compatible with dimmer controls.
   e. Sound data including results of operational tests of central dimming controls.
   f. Operational documentation for software and firmware.
2. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
   a. Include elevation views of front panels of control and indicating devices and control stations.
   b. Wiring Diagrams: Power, signal, and control wiring.
3. Samples: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.
   a. Operation and Maintenance Data: For central dimming controls with remote-mounting dimmers to include in emergency, operation, and maintenance manuals.
4. Warranty: Special warranty specified in this Section.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
3. Comply with NFPA 70.

F. Warranty
1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.
a. Failures include, but are not limited to, the following:
1) Damage from transient voltage surges.
b. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
c. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

G. Software Service Agreement
1. Services in this Article may not be allowed for publicly funded projects.
2. Technical Support: Beginning with Substantial Completion, provide software support for two years.
3. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
a. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. General System Requirements
1. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
2. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.
a. Alternative Line-Voltage Surge Suppression: Comply with requirements in Division 16 Section "Transient Voltage Suppression" for Category A **OR** B, **as directed**, locations.
3. Dimmers and Dimmer Modules: Comply with UL 508.
a. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

B. System Description
1. Description: Microprocessor-based, solid-state controls consisting of control stations and a separately mounted dimmer cabinet.
a. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a rocker switch **OR** pushbutton **OR** slider, **as directed**, is operated.
b. System control shall include master station(s), wall stations, and dimmer panels.
c. Each zone shall be configurable to control the following light sources:

1) Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
2) Line-voltage incandescent lamps.
3) Low-voltage incandescent lamps.
4) Cold cathode lamps.
5) Non-dimmed loads.
6) LED lamps.

d. Control of each zone shall interface with controls for the following accessory functions:
1) Curtains and drapes.
2) Blackout curtains.
3) Projector screens.
4) Motorized partitions.
5) Manually positioned partitions.

e. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.

C. Control Network
1. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.
2. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.
a. Control Voltage: 24- or 10-V dc.
b. Comply with USITT AMX 192 **OR** USITT DMX 512, **as directed**, for data transmission.

D. Master-Control Stations
1. Functions and Features:
a. Control adjustment of the lighting level for each scene of each zone, and adjustment of fade-time setting for each scene change from one preset scene to another. Controls shall use analog manual sliders **OR** digital rocker switches with LCD graphic display of light level, **as directed**.
b. Master channel shall raise and lower lighting level of all zones.
c. Fade rate for each scene shall be adjustable from zero to 60 seconds.
d. Fade override control for each scene.
e. Recall each preset scene and allow adjustment of zone controls associated with that scene.
f. Lockout switch to prevent changes when set.
g. On and off scene controls for non-dim channel contactors.
h. Emergency-control pushbutton to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
i. Master on and off switch; off position enables housekeeping controls.
j. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
k. Pushbuttons for accessory functions.
l. Enable and disable wall stations.
m. Communications link to other master stations.
n. Provide for connecting a portable computer to program the master station.
o. Rear-illuminate all scene-select buttons.
p. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.
2. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover, **as directed**.

E. Partitioned-Space Master-Control Station
1. Functions and Features:
a. Automatically combine and separate lighting and accessory function controls as spaces are configured with movable partitions; with controls for adjustment of the lighting level for

each scene of each dimmer, and adjustment of fade-rate setting for each scene change from one preset scene to another.

b. Master controls shall accommodate partitioning the space into six adjacent rooms.

c. Manual controls to set up six scenes for each room. Include wall stations in each room to control scenes.

d. Master channel to raise and lower the lighting level of all zones.

e. Adjustable fade rate for each scene from zero to 60 seconds.

f. Fade override control for each scene.

g. On and off scene controls for non-dim channel contactors.

h. Emergency-control pushbutton to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.

i. Master on and off switch; off position enables housekeeping controls.

j. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.

k. Pushbuttons for accessory functions.

l. Provide for connecting a portable computer to program the master station.

m. Rear-illuminate all scene-select buttons.

n. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.

2. Custom Graphics. Include a graphical display of room configurations and the names for each. Indicate the current spaces configuration with LCD graphic or LED-illuminated indicators, and show which wall stations are active. Inactive wall stations shall be automatically deactivated.

3. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover, **as directed**.

F. Wall Stations

1. Functions and Features:

a. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.

b. Controls to adjust the lighting level of each dimmer for each scene, and the fade time setting for each scene change from one preset scene to another.

c. Numbered pushbuttons to select scenes.

d. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting, **as directed**.

e. On switch turns all scenes of master station to full bright.

f. Pushbutton controls for accessory functions.

2. Mounting: Flush, wall box with manufacturer's standard faceplate.

3. Hand-held Cordless Control: Scene-select and accessory function pushbuttons using infrared **OR** radio-frequency, **as directed**, transmission.

G. Dimmer Cabinets

1. Factory wired, convection cooled without fans, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.

2. Ambient Conditions:

a. Temperature: 60 to 95 deg F (15 to 35 deg C).

b. Relative Humidity: 10 to 90 percent, noncondensing.

c. Filtered air supply.

3. Dimmer Cabinet Assembly: NRTL listed and labeled.

4. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.

a. Integrated Fault-Current Rating: 10,000-A RMS symmetrical.

5. Lighting Dimmers: Solid-state SCR dimmers.

a. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.

b. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IESNA's "IESNA Lighting Handbook."

c. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
d. Dimmed circuits shall be filtered to provide a minimum 350-mic.sec. current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load-current waveform.
e. Protect controls of each dimmer with a fuse and transient voltage surge suppression, **as directed**.

6. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.
7. Accessory function control modules shall be compatible with requirement of the accessory being controlled.
8. Digital Control Network:
   a. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
   b. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.
9. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.
   a. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
   b. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
   c. Integrated Fault-Current Rating: Same value as listed for the panel.
   d. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
   e. Fabricate and test dimmer boards to withstand seismic forces defined in Division 16 Section "Vibration And Seismic Controls For Electrical Systems".

H. Portable Computer
1. Description: As recommended by master-control station manufacturer, to program master station and associated wall stations, and all interconnected master stations, **as directed**. Portable computer shall be laptop style with a battery runtime of at least two hours. Display shall be an 11-inch (280-mm) interactive-matrix LCD and shall have required hardware, firmware, and software to program specified control functions of master-control stations.
2. Software shall be configured and customized by master-station manufacturer.

I. Manual Switches And Plates
1. Switches: Modular, momentary pushbutton, low-voltage type.
   a. Color: White unless otherwise indicated.
   b. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
   c. Locator Light: Internal illumination.
   d. Wall Plates: Comply with requirements in Division 16 Section "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
   e. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

J. Conductors And Cables
1. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Conductors And Cables".

2. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 16 Section "Conductors And Cables".
3. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG. Comply with requirements in Division 16 Section "Conductors And Cables".
4. Unshielded, Twisted-Pair Data Cable: Category 5e **OR** 6, **as directed**. Comply with requirements in Division 16 Section "Communications Horizontal Cabling".

1.3 EXECUTION

A. Wiring Installation
1. Comply with NECA 1.
2. Wiring Method:
   a. Comply with requirements in Division 16 Section "Conductors And Cables"
   b. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Division 16 Section "Communications Horizontal Cabling".
   c. Minimum conduit size shall be 1/2 inch (13 mm).
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
4. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
6. Install dimmer cabinets for each zone.

B. Identification
1. Comply with requirements in Division 16 Section "Electrical Identification" for identifying components and power and control wiring.
2. Label each dimmer module with a unique designation.
3. Label each scene control button with approved scene description.

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
   a. Continuity tests of circuits.
   b. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
      1) Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
   c. Emergency Power Transfer: Test listed functions.
3. Remove and replace malfunctioning dimming control components and retest as specified above.
4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

D. Demonstration

1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain central dimming controls. Laptop portable computer shall be used in training, **as directed**.
2. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 13 Section "Lighting Controls".

END OF SECTION 16930b

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SECTION 16930c - MODULAR DIMMING CONTROLS

1.1 GENERAL

A. Description Of Work
1. This specification covers the furnishing and installation of materials for modular dimming controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Summary
1. This Section includes the following:
a. Manual modular dimming controls.
b. Integrated, multipreset modular dimming controls.

C. Definitions
1. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
3. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
4. SCR: Silicon-controlled rectifier.
5. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

D. Submittals
1. Product Data: For each type of product indicated.
a. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
b. Device plates and plate color and material.
c. Ballasts and lamp combinations compatible with dimmers.
d. Wiring Diagrams: Power, signal, and control wiring.
2. Samples: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.

E. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

1.2 PRODUCTS

A. General Dimming Device Requirements
1. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
2. Dimmers and Dimmer Modules: Comply with UL 508.
a. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

B. Manual Modular Multiscene Dimming Controls
1. Description: Factory-fabricated equipment providing manual modular dimming control consisting of a wall-box-mounted, master-scene controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in one-, two-, or three-gang wall box under a single wall plate. Each zone station shall be adjustable to indicated number of scenes, which shall be recorded on the zone controller.
2. Operation: Automatically change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
3. Each manual modular multiscene dimming controller shall include a master control and remote controls.
4. Each zone shall be configurable to control the following:
   a. Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
   b. Incandescent lamps.
   c. Low-voltage incandescent lamps.
5. Memory: Retain preset scenes through power failures for at least seven days.
6. Device Plates: Style, material, and color shall comply with Division 16 Section "Wiring Devices".
7. Master-Scene Controller: Suitable for mounting in a single flush wall box.
   a. Switches: Master off, group dim, group bright, and selectors for each scene.
   b. LED indicator lights, one associated with each scene switch, and one for the master off switch.
8. Fluorescent Zone Dimmer: Suitable for operating lighting fixtures and ballasts specified in Division 16 Section "Interior Lighting", and arranged to dim number of scenes indicated for the master-scene controller. Scene selection is at the master-scene controller for setting light levels of each zone associated with scene.
   a. Switch: Rocker **OR** Slider, **as directed**, style for setting the light level for each scene.
   b. LED indicator lights, one associated with each scene.
   c. Electrical Rating: 1000 **OR** 2000, **as directed**, VA, 120 V.
9. Incandescent Zone Dimmer: Suitable for operating incandescent lamps at line-voltage or low-voltage lamps connected to a transformer and arranged to dim number of scenes indicated for the master-scene controller. Scene selection shall be at the master-scene controller for setting light levels of each zone associated with scene.
   a. Switch: Rocker **OR** Slider, **as directed**, style for setting the light level for each scene.
   b. LED indicator lights, one associated with each scene.
   c. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.

C. Integrated, Multipreset Modular Dimming Controls
1. Indicate number of wall-box, remote-control stations.
2. Description: Factory-fabricated, microprocessor-based, solid-state controls providing manual dimming control consisting of a master station and multiple wall-box, remote-control stations.
3. Operation: Automatically changes variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
4. Each zone shall be configurable to control the following:
   a. Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
   b. Incandescent lamps.
   c. Low-voltage incandescent lamps.
5. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.
6. Master Station:
   a. Contains control panel and multiple control and dimmer modules.
   b. Controls and commands adjustment of each dimmer-zone setting for each scene change from one preset scene to another.
      1) Master zone raises and lowers lighting level.
      2) Adjustable fade rate for each scene from 1 to 60 seconds.
   c. Rear-illuminated, scene-select buttons.

d. Lighting-level setting and fade-rate setting shall be graphically shown using LEDs or backlighted bar-graph indicator.
e. Mounting: Flush wall box with manufacturer's standard faceplate.

7. Remote-Control Stations:
   a. Numbered push buttons to select scenes.
   b. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting, **as directed**.
   c. On switch turns all scenes of master station to full bright.
   d. Control Wiring: NFPA 70, Class 2.
   e. Mounting: Single flush wall box with manufacturer's standard faceplate.
8. Infrared Remote-Control Station: Same functions as for standard remote-control station, except that functions are input by a hand-held infrared transmitter.
9. Dimmers: Modular, plug-in type, with circuit breaker to protect the dimmer and branch circuit.
   a. Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
   b. Dimming Curve: Modified "square law" as specified in IESNA's "IESNA Lighting Handbook"; control voltage is 0- to 10-V dc.
   c. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
   d. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.
   e. Short-Circuit Rating: 10 kA for 120 V, 14 kA for 277 V.

D. Conductors And Cables
1. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 16 Section "Conductors And Cables".
2. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 16 Section "Conductors And Cables".

1.3 EXECUTION

A. Wiring Installation
1. Comply with NECA 1.
2. Wiring Method: Comply with requirements in Division 16 Section "Conductors And Cables". Minimum conduit size shall be 1/2 inch (13 mm).
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
4. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

B. Identification
1. Comply with requirements in Division 16 Section "Electrical Identification" for identifying components and power and control wiring.
2. Label each dimmer module with a unique designation.
3. Label each scene control button with approved scene description.

C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
   a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:

a. Continuity tests of circuits.
b. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
1) Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

3. Remove and replace malfunctioning modular dimming control components and retest as specified above.
4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

D. Demonstration
1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls. Laptop portable computer shall be used in training, **as directed**.
2. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 13 Section "Lighting Controls".

END OF SECTION 16930c

Task	Specification	Specification Description
16933	16930a	Lighting Control Devices
16960	01352	No Specification Required
16990	16920a	Motor-Control Centers

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Task	Specification(s)
01352	01352
01510	01510
01520	01520, 01352
01540	01352
01550	01352
01560	01352
01580	01352
01590	01352
01660	01352
01720	01720
02011	02011
02111	02111, 02111a
02112	01720, 02111, 02111a
02115	02115, 02115a, 02115b, 02115c, 02115d
02119	01352
02201	01352
02203	02203, 02203a
02205	02203
02210	02210, 02203
02212	02212, 02203, 02203a
02213	02213, 01352, 02203
02215	02210, 02203
02223	02203
02224	02224
02242	02242, 02242a, 02242b, 02242c
02244	02244, 02244a
02261	02242b
02262	02262
02264	02264, 02264a, 02264b, 02242a
02411	02210
02452	02452
02455	02455, 02455a, 02455b, 02242, 02452
02456	02456, 02456a, 02456b, 02242
02459	02459, 02242, 02455a, 02213, 02452
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02462	01352, 02242, 02455b, 02452
02463	02455b
02464	02464, 02464a, 02464b, 01352, 02242, 02455a, 02456, 02455b, 02456a, 02213, 02452
02511	01352, 02242, 02455b, 02464b, 02213, 02452
02512	02242, 02213
02520	02242, 02452, 02242b
02522	02242, 02464, 02452
02525	02525, 01352, 02242, 02455b, 02452
02551	02551, 02551a, 01352, 02242
02553	02242
02555	02242, 02455a
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02561	02561, 01352, 02242, 02455b, 02452, 02242b
02570	02570, 02570a, 01352, 02242
02585	02561
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02612	02612, 02612a, 02612b
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02617	02617, 02617a, 02612
02618	02618, 02612, 02614
02620	02620, 02620a, 02614
02630	02630, 02630a, 02630b, 02630c, 02264b
02695	02620a
02710	02710, 01352
02711	01352, 02244, 02710
02712	02712, 02712a
02713	01352
02719	02719, 02719a
02720	02720, 02612
02721	02721, 01352
02722	02722
02725	02725, 02725a
02726	02726
02730	02730, 02730a, 02730b, 02730c, 02730d, 02730e, 02730f, 02730g, 01352
02731	02731, 02731a, 02730b
02735	01352, 02720
02764	02720
02765	01352, 02720
02805	02805
02810	02810, 02810a, 02810b, 02111a, 02244, 02203, 02203a, 02464b, 02805
02820	02805, 02810b
02831	01352, 02244, 02805, 02630c
02832	02810, 02630c
02840	02810, 02244
02845	02630c
02951	01352
02953	02953, 02242, 02570
02956	02956, 01352, 02242
03110	01352
03302	03302
03303	03302
03311	03302
03350	03302
03370	03370
03390	03302
03510	03510, 03510a
03620	03620
03630	01352
03640	01352, 03620
03920	03920
04110	04110
04130	04110
04160	04110
04170	04110
04180	04110
04205	04205, 04110
04210	04110
04213	04110
04220	04110

Task	Specification(s)
04221	04110
04222	04222, 03620, 04110
04240	04110
04251	04110
04270	04270, 04110
04285	04110
04286	04110
04410	04410, 04410a
04422	04422, 04410, 04410a
04423	04410, 04422, 04410a
04424	01352, 04410, 04422, 04410a
04426	01352, 04410, 04422, 04410a
04428	01352, 04410, 04422
04550	04110
04910	04910
04930	04910
05140	01352
05150	05500
05180	01352
05310	05310
05410	05410, 05410a, 03620, 05500
05500	05500
05501	05500
05504	05500
05505	05500
05506	01352, 05410a, 05500
05507	05500
05510	05510, 05510a, 05500
05511	05500, 05521
05521	05521, 05500
05530	01352, 05500
05535	05500
05540	05500
05720	05720, 05720a
05730	05730, 05720
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05805	05805
06110	06110, 06110a, 01352
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06415	06415, 06415a, 06410
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06450	06450, 01352, 06410
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07211	07210
07212	07212, 07212a, 07212b, 07212c, 07212d, 07212e, 07210
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07460	07460, 07460a, 07460b, 07460c, 07460d
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07533	07533, 07533a, 01352, 07212c
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07620	07620, 01352, 06110
07631	07631, 01352, 05720a, 07620
07650	01352, 07620
07660	01352, 07631
07670	07670, 01352
07713	01352
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07721	07310, 07670
07730	07670
07740	07670
07750	01352
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08110	08110, 08110a, 08354
08210	08210, 08210a, 01352
08301	08301
08305	08301
08310	08310
08316	08301
08325	01352
08330	08330
08340	08340, 01352

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08810	08810
08820	08810
08830	08830, 08810
08840	08840
08850	08810
08860	08860, 08810
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08875	08810
08890	08810
08912	08912, 08912a, 08912b
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09105	05410a
09110	09110
09205	09205, 09205a, 09205b, 09210
09210	09210, 09205
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09270	09250
09305	09205, 09250, 09250a, 09310
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09410	09410
09420	09410
09430	09430
09490	09410
09511	09511
09512	09512
09513	09513
09620	09620, 09620a, 09620b, 09620c
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09650	09650, 09650a, 09650b, 09650c, 01352, 09620b, 09620c
09660	09660

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09670	09430, 09620c
09680	09680, 09680a
09720	09720
09835	09835
09910	09910, 09910a, 09910b, 01352
09920	09920, 09920a, 09910
09925	09910
09930	09930, 09930a, 09910a
09945	03920
09949	09910a, 09910b
09952	09930a
09953	09930a
09954	09954
09955	09930a
09975	09975
09977	09930a
09979	09930a
10110	10110
10115	10110
10120	10110
10160	10160, 01352
10165	01352, 10160
10170	10170, 10160
10185	10160
10186	01352, 10160
10210	10210, 01352, 05720, 05730
10230	01352, 05500, 05720a
10261	10261, 05500
10263	10261
10271	10271
10291	02244a
10292	10292
10351	10351, 01352
10410	10110
10431	01352
10501	01352
10502	01352
10503	10503, 01352
10504	10503
10505	10505
10507	01352
10521	10521
10522	10522, 01352
10605	10605
10650	10650
10672	06110a
10710	10710, 01352
10810	10810, 10810a, 01352
10811	10810, 10810a
10812	10810
11021	08710a
11131	01352
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11163	11161
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11168	11161
11425	11425, 01352
11481	11481, 11481a
11910	11910, 11910a, 11910b, 11910c, 11910d
11920	11910
11940	01352
12201	12201
12210	12210, 12210a, 12210b, 12210c
12315	12315, 01352
12480	12480
12610	12610, 01352
12661	12661
13091	13091
13111	13111
13281	13281, 13281a, 13281b, 13281c, 01352
13283	13283
13285	13285, 13285a, 13285b, 13285c
13289	01352, 02115a, 13285, 13285a, 13285b, 13285c
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