CONTRACT DOCUMENTS
AND
SPECIFICATIONS
FOR
PROJECT NO. SP 22-7 TULSA POLICE
DEPARTMENT HELIPORT

ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

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CITY OF
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PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Sanitary waste piping exposed to freezing conditions.
4. Storm-water piping exposed to freezing conditions.
5. Roof drains and rainwater leaders.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material test reports.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
B. Comply with the following applicable standards and other requirements specified for miscellaneous components:


1.5 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
3. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS


B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.

1. Preformed Pipe Insulation: Type II, Class 1, unfaced.
2. Preformed Pipe Insulation: Type II, Class 2, with factory-applied ASJ, ASJ-SSL, ASJ+, or PSK jacket.
3. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.

G. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg and 220 deg F. Comply with ASTM C534/C534M, Type I for tubular materials.

H. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F in accordance with ASTM C411. Comply with ASTM C547.

1. Preformed Pipe Insulation: Type I, Grade A, unfaced with factory-applied ASJ, factory-applied ASJ-SSL, with factory-applied ASJ+ jacket, or with factory-applied PSK jacket.
2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 ADHESIVES

A. 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.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.

1. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
2. Wet Flash Point: Below 0 deg F.
3. Service Temperature Range: 40 to 200 deg F.

D. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

E. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
F. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

A. Materials shall be compatible with insulation materials, jackets, and substrates.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
   1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
   1. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm at manufacturer's recommended dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.

2.5 SEALANTS

A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.

B. Joint Sealants:
   1. Permanently flexible, elastomeric sealant.
   2. Service Temperature Range: Minus 58 to plus 176 deg F.
   3. Color: White or gray.

C. FSK and Metal Jacket Flashing Sealants:
   1. Fire- and water-resistant, flexible, elastomeric sealant.
   2. Service Temperature Range: Minus 40 to plus 250 deg F.

D. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:
   1. Fire- and water-resistant, flexible, elastomeric sealant.
   2. Service Temperature Range: Minus 40 to plus 250 deg F.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
5. PSK Jacket: Aluminum foil fiberglass reinforced scrim with polyethylene backing, complying with ASTM C1136, Type II.

2.7 FIELD-APPLIED JACKETS

A. C1136, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

   a. 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. Metal Jacket:


   a. Sheet and roll stock ready for shop or field sizing
   b. Finish and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   e. Factory-Fabricated Fitting Covers:

      1) Same material, finish, and thickness as jacket.
      2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
      3) Tee covers.
      4) Flange and union covers.
      5) End caps.
      6) Beveled collars.
      7) Valve covers.
      8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
E. Underground Direct-Buried Jacket: 125-mil-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.


G. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

1. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
2. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
3. Aluminum Finish: Embossed or Smooth.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.

B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in, in a Leno weave, for pipe.

2.9 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 6.5 mils.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Width: 2 inches.
2. Thickness: 6 mils.
4. Elongation: 150 percent.
5. Tensile Strength: 15 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

C. Wire: 0.062-inch soft-annealed, stainless steel.

2.11 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

1. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.
PART 3 - EXECUTION

3.1 PREPARATION

A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the contract documents.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.
   2. 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 attached to structure with vapor-barrier mastic.
   3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
   4. 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.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

L. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
   2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. 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 4 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.
   4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
   5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.

P. For above-ambient services, do not install insulation to the following:
   1. Vibration-control devices.
   2. Testing agency labels and stamps.
   3. Nameplates and data plates.
3.3 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. 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.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. 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.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistant joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of 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.

3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that 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.

4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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.

5. Insulate strainers using preformed fitting insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 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.

6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.

7. 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.

8. 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.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. 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.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 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.
3. 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.

4. 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 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.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. 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 that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Install jacket material with manufacturer’s recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer’s written instructions.
2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. 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.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. 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 that of pipe insulation.
4. 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.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
2. 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated 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.
3. Install insulation to flanges as specified for flange insulation application.
4. 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.

3.7 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:
1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated 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.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
D. Where metal jackets are indicated, install with 2-inch 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 o.c. and at end joints.

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. 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.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless steel jackets.

3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, 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.

C. All insulation applications will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.11 PIPING INSULATION SCHEDULE, GENERAL

A. 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.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 and Smaller: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1/2 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

2. NPS 1-1/4 and Larger: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 and Smaller: Insulation shall be one of the following:
   a. Flexible Elastomeric: 1 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/2 and Larger: Insulation shall be one of the following:
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.

C. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: 3/4 inch thick.
   b. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Domestic Water Piping:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 2 inches thick.

B. Domestic Hot and Recirculated Hot Water:

1. All Pipe Sizes: Insulation shall be the following:
   a. Flexible Elastomeric: 2 inches thick.
3.14 **INDOOR, FIELD-APPLIED JACKET SCHEDULE**

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. PVC, Color-Coded by System: 20 mils thick.

3.15 **OUTDOOR, FIELD-APPLIED JACKET SCHEDULE**

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:
   1. None.

D. Piping, Exposed:
   1. PVC: 30 mils thick.
   2. Aluminum, Smooth: 0.020 inch thick.

**END OF SECTION**
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. 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. Potable-water piping and components shall comply with NSF 14 and NSF 61. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.

B. Soft Copper Tube: ASTM B 88, Type L water tube, annealed temper.

C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.


E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

F. Copper Unions:

1. MSS SP-123.
4. Solder-joint or threaded ends.

G. Copper Pressure-Seal-Joint Fittings:

1. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
2. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.

H. Copper-Tube, Extruded-Tee Connections:
1. Description: Tee formed in copper tube according to ASTM F 2014.

I. Appurtenances for Grooved-End Copper Tubing:

1. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 copper tube or ASTM B 584 bronze castings.
2. Mechanical Couplings for Grooved-End Copper Tubing:
   a. Copper-tube dimensions and design similar to AWWA C606.
   b. Ferrous housing sections.
   c. EPDM-rubber gaskets suitable for hot and cold water.
   d. Bolts and nuts.
   e. Minimum Pressure Rating: 300 psig.

2.3 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

2. Pressure Rating: 125 psig minimum at 180 deg F.

C. Dielectric Flanges:

2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 125 psig minimum at 180 deg F.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Nonconducting materials for field assembly of companion flanges.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

2. Electroplated steel nipple complying with ASTM F 1545.
3. Pressure Rating and Temperature: 300 psig at 225 deg F.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.
PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. 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.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance.

D. Install shutoff valve immediately upstream of each dielectric fitting.

E. Install water-pressure-reducing valves downstream from shutoff valves.

F. Install domestic water piping level and plumb.

G. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

H. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

I. 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.

J. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

K. Install piping to permit valve servicing.

L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

P. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump.

Q. Install thermostats in hot-water circulation piping.

R. Install thermometers on inlet and outlet piping from each water heater.
S. Install sleeves for piping penetrations of walls, ceilings, and floors.

T. Install sleeve seals for piping penetrations of concrete walls and slabs.

U. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.2 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.

D. Soldered Joints for Copper Tubing: 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."

E. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

F. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Insert copper tube and push-on joint fittings by inserting tube to measured depth.

G. 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.

H. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.

I. 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.

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.
3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with the following requirements for pipe hanger, support products, and installation.

1. Vertical Piping: MSS Type 8 or 42, clamps.
2. Individual, Straight, Horizontal Piping Runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.

D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

   1. NPS 3/4 and Smaller: 60 inches with 3/8-inchrod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inchrod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inchrod.
   4. NPS 2-1/2: 108 inches with 1/2-inchrod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inchrod.
   6. NPS 6: 10 feet with 5/8-inchrod.
   7. NPS 8: 10 feet with 3/4-inchrod.

E. Install supports for vertical copper tubing every 10 feet.

F. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

   1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
   2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
4. 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 and larger.

3.6 IDENTIFICATION

A. Identify system components.
   1. Provide valve tags and valve schedule.
   2. Label piping every 8' with system designation and flow arrows.

B. Label pressure piping with system operating pressure.

3.7 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

   1. 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 for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph 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.

   2. 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 above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it 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.

B. Domestic water piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.8 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
   a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
   b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.9 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. 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:
   a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
   b. Fill and isolate system according to either of the following:
      1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
   c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
   d. Repeat procedures if biological examination shows contamination.
   e. Submit water samples in sterile bottles to authorities having jurisdiction.
B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.10 PIPING SCHEDULE

A. See Drawings.

3.11 VALVE SCHEDULE

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.

B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION
SECTION 221316
SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:


1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For sovent drainage system. Include plans, elevations, sections, and details.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. 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.

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.
2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
   2. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Cast-Iron, Hubless-Piping Couplings:
   2. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.

B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.

D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.

E. Copper Pressure Fittings:
   2. 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.

F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

   1. Basis-of-Design Product: Manufacturers: Subject to compliance with requirements, provide products by LASCO Fittings, Inc. or comparable product by one of the following:

      a. NIBCO INC.
      b. Spears Manufacturing Company.

D. Adhesive Primer: ASTM F 656.

   1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

E. Solvent Cement: ASTM D 2564.

   1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

   1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
   2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
   3. Unshielded, Nonpressure Transition Couplings:

      b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
      c. Sleeve Materials:


   4. Shielded, Nonpressure Transition Couplings:

      b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Dielectric Fittings:
1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

2. Dielectric Unions:
   a. Description:
      1) Standard: ASSE 1079.
      2) Pressure Rating: 125 psig at 180 deg F.
      3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric-Flange Insulating Kits:
   a. Description:
      1) Nonconducting materials for field assembly of companion flanges.
      2) Pressure Rating: 150 psig.
      3) Gasket: Neoprene or phenolic.
      4) Bolt Sleeves: Phenolic or polyethylene.
      5) Washers: Phenolic with steel backing washers.

4. Dielectric Nipples:
   a. Description:
      1) Standard: IAPMO PS 66
      2) Electroplated steel nipple.
      3) Pressure Rating: 300 psig at 225 deg F.
      4) End Connections: Male threaded or grooved.
      5) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. 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.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. 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.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.
F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. 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 two 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.

K. 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.

L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. 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."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.

N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

O. Install engineered soil and waste drainage and vent piping systems as follows:

2. Sovent Drainage System: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

P. Plumbing Specialties:

1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping.

Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
R. Install sleeves for piping penetrations of walls, ceilings, and floors.
S. Install sleeve seals for piping penetrations of concrete walls and slabs.
T. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.2 JOINT CONSTRUCTION


C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

D. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

E. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.

F. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

G. Plastic, Nonpressure-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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.3 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
3. Dielectric Fittings for NPS 2-1/2 and larger: Use dielectric flange kits.
3.4 VALVE INSTALLATION

A. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install gate or full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

B. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with the following requirements for pipe hanger and support devices and installation.

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
5. Vertical Piping: MSS Type 8 or Type 42, clamps.
6. Install individual, straight, horizontal piping runs:
   a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
8. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.

C. Support vertical piping and tubing at base and at each floor.

D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.

E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inchrod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inchrod.
4. NPS 6 and NPS 8: 60 inches with 3/4-inchrod.
5. NPS 10 and NPS 12: 60 inches with 7/8-inchrod.

F. Install supports for vertical cast-iron soil piping every 15 feet.

G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4: 72 inches with 3/8-inchrod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.

H. Install supports for vertical copper tubing every 10 feet.

I. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
   2. NPS 3: 48 inches with 1/2-inch rod.
   3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
   4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.

J. Install supports for vertical PVC piping every 48 inches.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
   5. 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 and larger.

D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

E. Make connections according to the following unless otherwise indicated:
   1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
   2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

A. Identify exposed sanitary waste and vent piping every 8’ with system labels and flow arrows.
3.8 FIELD QUALITY CONTROL

A. 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.

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 for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. 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.
2. 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.
3. 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. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. 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. 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.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.9 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.
3.10 PIPING SCHEDULE

A. See Drawings.

END OF SECTION
SECTION 221513
GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes piping and related specialties for general-service compressed-air systems, as follows:

1. Pipes, tubes, and fittings.
2. Joining materials.
3. Valves.
4. Dielectric fittings.
5. Flexible pipe connectors.
7. Quick couplings.
8. Hose assemblies.

B. Related Requirements:

1. Section 231519 "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.2 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. Low-Pressure, Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig or less.

C. NBR: Nitrile butadiene rubber.

D. PE: Polyethylene plastic.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Dielectric fittings.
2. Flexible pipe connectors.
4. Pressure regulators. Include rated capacities and operating characteristics.
5. Quick couplings.
6. Hose assemblies.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

1. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by respective manufacturer, for making branch outlets.
2. Press-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by respective manufacturer.
3. Pressure-Seal Joining Procedure for Steel Piping. Qualify operators according to training provided by respective manufacturer.
4. Joining Procedures for Aluminum Piping Systems: Qualify installers according to training provided by respective manufacturer.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain each product type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. ASME Compliance:


2.3 PIPES, TUBES, AND FITTINGS

A. Schedule 40, Steel Pipe: ASTM A53/A53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded in accordance with ASME B1.20.1.


B. Copper Tube: ASTM B88, Type K seamless, drawn-temper, water tube.
1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
3. Copper Unions: ASME B16.22 or MSS SP-123.
4. Press-Type, Copper Tube, Fittings, NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
5. Press-Type, Copper Tube, Fittings, NPS 2-1/2 to NPS 4: Bronze fitting with stainless steel grip ring and EPDM O-ring seal in each end.

C. 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.

D. Aluminum Piping System: Aluminum pipe, Alloy Grade AA 6035-T5, for push-connect bite ring couplings, and roll-groove couplings.

1. Pressure and Temperature Range: Aluminum piping and related specialties for general-service compressed-air systems operating at 220 psig or less, across a temperature range of minus 4 to plus 176 deg F.
2. Tubing, 14 to 273 mm: Aluminum pipe, Alloy Grade AA 6063-T5.
3. Pipe Coating: Powder-coated paint that is certified nontoxic to AAMA 603 and AAMA 605, blue for compressed air.
4. Provide tubing that is quality controlled to comply with tolerances specified by roll-groove or push-to-connect coupling manufacturer. Tubing manufacturer follows ISO 9001:2000 quality standards.
5. Pipe Identification: Decal with maximum working pressure and temperature on each length of pipe.
6. Push-Connect Bite Ring Couplings, 14 to 63 mm: Solid-brass and nickel-plated body, NBR O-ring seal in excess of 36 percent, and AISI Type 304 stainless steel clamping washer.
7. Fittings: Solid brass and nickel plated.
8. Ball Valves, 20 to 63 mm: NPT ends, or push-connect bite ring ends.
9. Butterfly Valves, 73 to 273 mm: Tube to tube, with two roll-groove end couplings.

2.4 JOINING MATERIALS

A. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux in accordance with ASTM B813.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
1. Description:
   b. Pressure Rating: 150 psig.
   c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Description:
      b. Factory-fabricated, bolted, companion-flange assembly.
      c. Pressure Rating: 150 psig.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

2.6 FLEXIBLE PIPE CONNECTORS

A. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
   2. End Connections, NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
   3. End Connections, NPS 2-1/2 and Larger: Flanged copper alloy.

B. Stainless Steel-Hose Flexible Pipe Connectors: Corrugated, stainless steel tubing with stainless steel wire-braid covering and ends welded to inner tubing.
   2. End Connections, NPS 2 and Smaller: Threaded steel pipe nipple.
   3. End Connections, NPS 2-1/2 and Larger: Flanged steel nipple.

2.7 SPECIALTIES

A. 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.
   1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

B. Air-Main Pressure Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250 psig inlet pressure, unless otherwise indicated.
   1. Type: Pilot operated.
2.8 QUICK COUPLINGS

A. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.

B. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless steel or nickel-plated-steel operating parts.
   1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.

C. Valveless Quick Couplings: Straight-through brass body with stainless steel or nickel-plated-steel operating parts.
   1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.

2.9 HOSE ASSEMBLIES

A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300 psig minimum working pressure, unless otherwise indicated.
   2. Hose Clamps: Stainless steel clamps or bands.
   3. 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.
   4. Hose Splicers: One-piece, straight-through brass or stainless steel fitting with barbed ends for connecting two sections of hose.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Low-Pressure Compressed-Air Distribution Piping: Use one of the following piping materials for each size range:
   1. NPS 2 and Smaller, Threaded: Schedule 40, black-steel pipe; threaded, malleable-iron fittings; and threaded joints.
   2. NPS 2 and Smaller, Brazed: Type K, copper tube; wrought-copper fittings; and brazed joints.
   3. NPS 2 and Smaller, Pressure-Sealed, Copper: Type K, copper tube; press-type fittings; and pressure-sealed joints.
   4. NPS 2 and Smaller: Aluminum pipe; solid-brass nickel-plated fittings; and push-connect bite ring couplings.

B. Drain Piping: Use one of the following piping materials:
   1. NPS 2 and Smaller: Type M copper tube; wrought-copper fittings; and brazed or soldered joints.
2. NPS 2 and Smaller: Aluminum pipe; solid-brass nickel-plated fittings; and push-connect bite ring couplings.

3.2 VALVE APPLICATIONS

A. Metal General-Duty Valves:
   1. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.
   2. Equipment Isolation NPS 2 and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

B. General-Duty Valves for Aluminum Piping System: Provide valves, made by piping system manufacturer, that are compatible with piping.
   1. Ball Valves, NPS 2 and Smaller: NPT ends, or push-connect bite ring ends.

3.3 INSTALLATION OF PIPING, GENERAL

A. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

B. 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.

C. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

D. Where installing piping adjacent to equipment and machines, allow space for service and maintenance.

E. Install air and drain piping with 1 percent slope downward in direction of flow.

F. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating unless otherwise indicated.

G. 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, in accordance with Extruded Tee Connections Sizes and Wall Thickness for Copper Tube (Inches) Table in ASTM F2014.

H. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

I. 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.

J. Install pressure gauge on discharge piping from each air compressor and on each receiver.

K. Install piping to permit valve servicing.
L. Install piping free of sags and bends.
M. Install fittings for changes in direction and branch connections.
N. Install sleeves for piping penetrations of walls, ceilings, and floors.
O. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 INSTALLATION OF ALUMINUM PIPING SYSTEMS

A. Install aluminum piping systems in accordance with manufacturer's written instructions, using manufacturer's recommended tools, accessories, and methods.

B. Install branch connections NPS 2 and smaller, to compressed-air mains using aluminum piping system reducing outlet tee with water trapping capabilities. Provide drain leg and drain trap at end of each main and branch and at low points.

C. Support aluminum pipe using manufacturer's hangers and supports, designed for use with the system.

D. Allow for expansion and contraction of aluminum piping system.

E. Do not use plastic components or plastic fittings of any kind within pressurized aluminum piping system. This limitation applies to main headers, branches, and drops.

3.5 JOINT CONSTRUCTION

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. Threaded Joints: Thread pipe with tapered pipe threads in accordance with 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:

   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
   2. 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.

D. Brazed Joints for Copper Tubing: Join in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

E. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Join in accordance with ASTM B828 or CDA's "Copper Tube Handbook."

F. Extruded-Tee Outlets for Copper Tubing: Form branches in accordance with ASTM F2014, with tools recommended by procedure manufacturer, and using operators qualified in accordance with "Quality Assurance" Article.
G. Press-Sealed Joints: Join with tools recommended by fitting manufacturer, using operators qualified in accordance with "Quality Assurance" Article.

H. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.6 INSTALLATION OF DIELECTRIC FITTINGS

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. NPS 2 and Smaller: Use dielectric unions.

3.7 INSTALLATION OF FLEXIBLE PIPE CONNECTORS

A. Install flexible pipe connectors in discharge piping of each air compressor.

B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.

C. Install stainless steel-hose flexible pipe connectors in steel compressed-air piping.

3.8 INSTALLATION OF SPECIALTIES

A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.

B. Install air-main pressure regulators in compressed-air piping at or near air compressors.

C. Install quick couplings at piping terminals for hose connections.

D. Install hose assemblies at hose connections.

3.9 PIPING CONNECTIONS

A. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.

3.10 INSTALLATION OF HANGERS AND SUPPORTS

A. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

B. Install hangers for aluminum piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

C. Support horizontal piping within 12 inches of each fitting and coupling.
D. Support vertical runs of copper tubing and steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

E. Support vertical runs of aluminum piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

F. Individual, Straight, Horizontal Piping Runs:
   1. 100 Ft. or Less: MSS Type 1, adjustable, steel clevis hangers.
   2. Longer Than 100 Ft.: MSS Type 43, adjustable roller hangers.

G. Multiple, Straight, Horizontal Piping Runs 100 Ft. or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

H. Base of Vertical Piping: MSS Type 52, spring hangers.

3.11 LABELING AND IDENTIFICATION

A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties.

3.12 FIELD QUALITY CONTROL

A. Perform field tests and inspections.

B. Tests and Inspections:
   1. 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 above system operating pressure, but not less than 150 psig. 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.
   2. Piping Leak Tests for Aluminum Compressed-Air Piping: Test new piping system and modified parts of existing piping system. Cap and fill general-service compressed-air piping system to pressure of 15 psig, hold pressure for 10 minutes. Repeat until reaching required operating pressure, not to exceed 220 psig. Once desired operating pressure is met, let stand for one hour.
   3. Repair leaks and retest until no leaks exist.
   4. Inspect filters and pressure regulators for proper operation.

C. Prepare test and inspection reports.

END OF SECTION
SECTION 221519

GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Lubricated, reciprocating air compressors.
   2. Inlet-air filters.
   3. Air-cooled, compressed-air aftercoolers.
   5. Refrigerant compressed-air dryers.

1.2 DEFINITIONS

A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm.

B. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For compressed-air equipment to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Air-Compressor, Inlet-Air-Filter Elements: One for each compressor.
   2. Belts: One for each belt-driven compressor.
1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. 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.

B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

2.2 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

A. 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.

B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.

1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
3. Control Voltage: 120-V ac or less, using integral control power transformer.
5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
7. Alarm Signal Device: For connection to alarm system to indicate when air compressor is not operating correctly.

C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.

2.3 LUBRICATED, RECIPROCATING AIR COMPRESSORS

A. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.
1. Submerged gear-type oil pump.
2. Oil filter.
3. Combined high discharge-air temperature and low lubrication-oil pressure switch.

2.4 INLET-AIR FILTERS

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.5 REFRIGERANT COMPRESSED-AIR DRYERS

A. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 deg F, 100-psig 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.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Equipment Mounting:

1. Install air compressors and air dryers on cast-in-place concrete equipment base(s).

B. Install compressed-air equipment anchored to substrate.

C. Arrange equipment so controls and devices are accessible for servicing.

D. Maintain manufacturer's recommended clearances for service and maintenance.

E. Install the following devices on compressed-air equipment:

1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
2. Pressure Regulators: Install downstream from air compressors and dryers.
3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.2 CONNECTIONS

A. Comply with requirements for piping specified in Section 221513 "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
B. Where installing piping adjacent to machine, allow space for service and maintenance.

3.3 IDENTIFICATION

A. Identify general-service air compressors and components.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer’s written instructions.
2. Check for lubricating oil in lubricated-type equipment.
3. Check belt drives for proper tension.
4. Verify that air-compressor inlet filters and piping are clear.
5. Check for equipment vibration-control supports and flexible pipe connectors, and verify that equipment is properly attached to substrate.
6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure, but not higher than rating of system components.
7. Drain receiver tanks.
8. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
9. Test and adjust controls and safeties.

3.5 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air compressors and air dryers.

END OF SECTION
SECTION 223400
GAS-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

   1. Direct-vent, gas-fired, storage, domestic-water heaters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. 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.

B. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.

C. ASME Compliance:

   1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

   2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.
D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.6 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including storage tank and supports.
   b. Faulty operation of controls.
   c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.
   a. Gas-Fired, Storage, Domestic-Water Heaters:
      1) Storage Tank: Five years.
      2) Controls and Other Components: One year.

PART 2 - PRODUCTS

2.1 GAS-Fired, STORAGE, domestic-WATER HEATERS

A. Direct-Vent, Gas-Fired, Storage, Domestic-Water Heaters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product.


   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

4. Factory-Installed Storage-Tank Appurtenances:
   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
   c. Drain Valve: ASSE 1005.
   d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
   e. Jacket: Steel with enameled finish.
   f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
g. Burner: For use with direct-vent, gas-fired, domestic-water heaters and natural-gas fuel.

h. Automatic Ignition: ANSI Z21.20/CSA C22.2 No. 199, electric, automatic, gas-ignition system.

i. Temperature Control: Adjustable thermostat.

j. Combination Temperature-and-Pressure Relief Valve: ANSI Z21.22/CSA 4.4-M. Include relieving capacity at least as great as heat input and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

5. Direct-Vent System: Through-roof, coaxial- or double-channel vent assembly with domestic-water heater manufacturers outside intake/exhaust screen.

2.2 Domestic-WATER HEATER ACCESSORIES

A. Domestic-Water 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.

2. Construction:
   a. Tapping's: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.


D. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include pressure rating as required to match gas supply.

E. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.


F. Pressure Relief Valves: Include pressure setting less than domestic-water heater working-pressure rating.


G. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.
2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect assembled domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 014000 "Quality Requirements" for retesting and reinspecting requirements and Section 017300 "Execution" for requirements for correcting the Work.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC WATER HEATER INSTALLATION


1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
2. Maintain manufacturer's recommended clearances.
3. Arrange units so controls and devices that require servicing are accessible.
4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
7. Install anchor bolts to elevations required for proper attachment to supported equipment.
8. Anchor domestic-water heaters to substrate.

B. Install domestic-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.

1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping.

C. Install gas-fired, domestic-water heaters according to NFPA 54.

1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 231123 "Facility gas Piping."
D. 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.

E. 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 domestic-water heaters that do not have tank drains.

F. Install thermometer on outlet piping of domestic-water heaters.

G. Fill domestic-water heaters with water.

H. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

A. Comply with requirements for domestic-water piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for gas piping specified in Section 231123 "Facility gas Piping."

C. Drawings indicate general arrangement of piping, fittings, and specialties.

D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

A. Identify system components.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.

4. Test and adjust controls and safety. Replace damaged and malfunctioning controls and equipment.

B. Domestic-water heaters will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.
3.5 DEMONSTRATION

A. Train Owner’s maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage domestic-water heaters.

END OF SECTION
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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Water closets.
      a. Toilet seats.
   2. Lavatories
      a. Faucets.
   3. Sinks
      a. Faucets.
   4. Drinking Fountains – Wall mounted
   5. Showers

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
   1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.
PART 2 - PRODUCTS

2.1 See plumbing schedule on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before fixture installation.

B. Examine walls and floors for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TOILET INSTALLATION

A. Water-Closet Installation:

1. Install level and plumb according to roughing-in drawings.
2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.

B. Install toilet seats on water closets.

C. Joint Sealing:

1. Seal joints between water closets and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.

3.3 TOILET CONNECTIONS

A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

D. Where installing piping adjacent to water closets, allow space for service and maintenance.
3.4 TOILET ADJUSTING

A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.

3.5 TOILET CLEANING AND PROTECTION

A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.

B. Install protective covering for installed water closets and fittings.

C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

3.6 LAVATORY INSTALLATION

A. Install lavatories level and plumb according to roughing-in drawings.

B. Install supports, affixed to building substrate, for wall-mounted lavatories.

C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.

E. Seal joints between lavatories and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Indicate on Drawings those lavatories that are required to be accessible.

F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories.

G. Install mixing valve per manufacturer’s instructions.

3.7 LAVATORY CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.8 LAVATORY ADJUSTING

A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
B. Adjust water pressure at faucets to produce proper flow.

3.9 LAVATORY CLEANING AND PROTECTION

A. After completing installation of lavatories, inspect and repair damaged finishes.

B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed lavatories and fittings.

D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

3.10 SINK INSTALLATION

A. Install sinks level and plumb according to roughing-in drawings.

B. Install water-supply piping with stop on each supply to each sink faucet.

C. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.

D. Seal joints between sinks and counters using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Indicate on Drawings those sinks that are required to be accessible.

E. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks.

F. Install mixing valve per manufacturer’s instructions.

3.11 SINK CONNECTIONS

A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.12 SINK ADJUSTING

A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.
3.13 SINK CLEANING AND PROTECTION

A. After completing installation of sinks, inspect and repair damaged finishes.

B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed sinks and fittings.

D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

3.14 DRINKING FOUNTAIN INSTALLATION

A. Install fixtures level and plumb according to roughing-in drawings provided by manufacturer.

B. Install water-supply piping and shutoff valve on supply to each fixture to be connected to domestic-water distribution piping.

C. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings.

E. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

3.15 DRINKING FOUNTAIN CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Install ball, gate, or globe shutoff valve on water supply to each fixture.

D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.16 DRINKING FOUNTAIN ADJUSTING

A. Adjust fixture flow regulators for proper flow and stream height.

3.17 DRINKING FOUNTAIN CLEANING

A. After installing fixtures, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
B. Clean fixtures, on completion of installation, according to manufacturer’s written instructions.

C. Provide protective covering for installed fixtures.

D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

3.18 SHOWER INSTALLATION

A. Assemble shower components according to manufacturers’ written instructions.

B. Install showers level and plumb according to roughing-in drawings.

C. Install water-supply piping with stop on each supply to each shower faucet.
   1. Exception: Use ball, gate, or globe valves if supply stops are not specified with shower.
   2. Install stops in locations where they can be easily reached for operation.

D. Install shower flow-control fittings with specified maximum flow rates in shower arms.

E. Set shower basins in leveling bed of cement grout.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.

G. Seal joints between showers and floors and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.19 SHOWER CONNECTIONS

A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."

C. Comply with traps and soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.20 SHOWER ADJUSTING

A. Operate and adjust showers and controls. Replace damaged and malfunctioning showers, fittings, and controls.

B. Adjust water pressure at faucets to produce proper flow.

3.21 SHOWER CLEANING AND PROTECTION

A. After completing installation of showers and basins, inspect and repair damaged finishes.
B. Clean showers and basins, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.

C. Provide protective covering for installed fixtures and fittings.

D. Do not allow use of showers and basins for temporary facilities unless approved in writing by Owner.

END OF SECTION
SECTION 230593
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Balancing Air Systems:
      a. Constant-volume air systems.

1.3 DEFINITIONS


C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 15 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.


D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:
1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB, or TABB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB, or TABB as a TAB technician.

B. Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.


D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. 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.

B. 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.

C. Examine the approved submittals for HVAC systems and equipment.
D. 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.

E. 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 Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

   1. 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.
   2. 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.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. 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.

J. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

K. Examine operating safety interlocks and controls on HVAC equipment.

L. 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.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

   1. Permanent electrical-power wiring is complete.
   2. Automatic temperature-control systems are operational.
   3. Equipment and duct access doors are securely closed.
   4. Balance, smoke, and fire dampers are open.
   5. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
   6. Windows and doors can be closed so indicated conditions for system operations can be met.
3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation."

C. 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.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. 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.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. 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.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Check for proper sealing of air-handling-unit components.

K. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."
3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.
   a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:
   a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. 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.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.

5. 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.

6. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.

7. 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.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.
   a. 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.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer’s written instructions and calculating factors.

D. 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.

1. 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.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 TOLERANCES

A. Set HVAC system’s air flow rates and water flow rates within the following tolerances:

1. Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
4. Outside air: Minus 10 percent.

3.7 REPORTING

A. 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.

B. Status Reports: Prepare weekly 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.

3.8 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. Final Report Contents: In addition to certified field-report data, include the following:
1. Fan curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
   a. Indicated versus final performance.
   b. Notable characteristics of systems.
   c. Description of system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outdoor-, return-, and exhaust-air dampers.
   b. Conditions of filters.
   c. Cooling coil, wet- and dry-bulb conditions.
   d. Face and bypass damper settings at coils.
   e. Fan drive settings including settings and percentage of maximum pitch diameter.
   f. Inlet vane settings for variable-air-volume systems.
   g. Settings for supply-air, static-pressure controller.
   h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches, and bore.
      i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
   j. Number, make, and size of belts.
   k. Number, type, and size of filters.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.

3. Test Data (Indicated and Actual Values):
   a. Total air flow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches wg.
   g. Cooling-coil static-pressure differential in inches wg.
   h. Heating-coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch. c.
   f. Make and model number.
   g. Face area in sq. ft.
   h. Tube size in NPS.
i. Tube and fin materials.

j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Fuel type in input data.
   g. Output capacity in Btu/h.
   h. Ignition type.
   i. Burner-control types.
   j. Motor horsepower and rpm.
   k. Motor volts, phase, and hertz.
   l. Motor full-load amperage and service factor.
   m. Sheave make, size in inches, and bore.
   n. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

   a. Total air flow rate in cfm.
   b. Entering-air temperature in deg F.
   c. Leaving-air temperature in deg F.
   d. Air temperature differential in deg F.
   e. Entering-air static pressure in inches wg.
   f. Leaving-air static pressure in inches wg.
   g. Air static-pressure differential in inches wg.
   h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches, and bore.
   h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:
   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
   g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
   a. System and air-handling-unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F.
   d. Duct static pressure in inches wg.
   e. Duct size in inches.
   f. Duct area in sq. ft.
   g. Indicated air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

J. Instrument Calibration Reports:

1. Report Data:
   a. Instrument type and make.
   b. Serial number.
   c. Application.
   d. Dates of use.
   e. Dates of calibration.

3.9 INSPECTIONS

A. Initial Inspection:

1. 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.
2. Check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   c. Verify that balancing devices are marked with final balance position.
   d. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. 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 Architect.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect 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.
4. 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."
5. 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.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. 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.
2. 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.

D. Prepare test and inspection reports.

3.10 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. 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
SECTION 230713
DUCT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes insulating the following duct services:
   1. Indoor, concealed supply and outdoor air.

B. Related Sections:
   1. Section 233113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
   2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
   3. Detail application of field-applied jackets.
   4. Detail application at linkages of control devices.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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 agency.

   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
1.4 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

A. Coordinate clearance requirements with duct installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS


B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. 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.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.

G. 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.
2.2 ADHESIVES

A. 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.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
   1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

   1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
   1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
   1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
   2. Service Temperature Range: Minus 20 to plus 180 deg F.
   3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
   1. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
2. Service Temperature Range: 0 to 180 deg F.

2.4 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
   1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
   3. Service Temperature Range: 0 to plus 180 deg F.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
   1. Materials shall be compatible with insulation materials, jackets, and substrates.
   2. Fire- and water-resistant, flexible, elastomeric sealant.
   3. Service Temperature Range: Minus 40 to plus 250 deg F.
   5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   6. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
   1. Verify that systems to be insulated have been tested and are free of defects.
   2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. 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.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

   1. Install insulation continuously through hangers and around anchor attachments.
   2. 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.
   3. 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.

J. Apply adhesives, mastics, and sealants at manufacturer’s recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:

   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

      a. For below ambient services, apply vapor-barrier mastic over staples.

   4. Cover joints and seams with tape, according to insulation material manufacturer’s written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. 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.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. 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.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: 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.

1. Comply with requirements in Section 078413 "Penetration Firestopping" firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:
1. Duct: 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.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. 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.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. 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:
   a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
   b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   d. Do not overcompress insulation during installation.
   e. Impale insulation over pins and attach speed washers.
   f. 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.
4. 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 from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
   b. Install vapor stops for ductwork and plenums operating below 50 deg at 18-foot 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 two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. 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.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:
   1. Indoor, concealed supply and outdoor air.
   2. Exhaust duct between the backdraft damper and building exterior.

B. Items Not Insulated:
   1. Fibrous-glass ducts.
   2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
   3. Factory-insulated flexible ducts.
   5. Flexible connectors.
   7. Factory-insulated access panels and doors.

3.8 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. See Drawings.
SECTION 231113
FACILITY FUEL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fuel pipes, tubes, and fittings.
2. Piping specialties.
4. Specialty valves.
5. Labels and identification.

1.3 DEFINITIONS

A. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. For valves, include pressure rating, capacity, settings, and electrical connection data of selected models.

B. Shop Drawings: For fuel piping.

1. Include plans, elevations sections, hangers, and supports for multiple pipes.
2. Include details of location of anchors, alignment guides, and expansion joints and loops.
3. Scale: 1/4 inch per foot.

C. Delegated-Design Submittal: For fuel piping indicated to comply with performance requirements and design criteria.
1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Plans and details, drawn to scale, on which fuel piping is shown and coordinated with other installations, using input from installers of the items involved.
2. Site Survey: Plans, drawn to scale, on which fuel piping and tanks are shown and coordinated with other services and utilities.

B. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel equipment and accessories to include in operation and maintenance manuals.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Lift and support fuel storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

B. 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.

C. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.

D. Store PE pipes and valves protected from direct sunlight.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fiberglass piping and related equipment that fail in materials or workmanship within specified warranty period.

1. Failures due to defective materials or workmanship for materials including piping, dispenser sumps, water-tight sump entry boots, terminations, and other end fittings.
2. Warranty Period: 1 year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. 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.
B. Comply with requirements of the OCC and local authorities having jurisdiction. Include registration of fuel piping.

2.2 FUEL PIPES, TUBES, AND FITTINGS

A. See "Outdoor Piping Installation" and articles for where pipes, tubes, fittings, and joining materials are applied in various services.

B. Steel Pipe: ASTM A 53/A 53M, stainless steel, Schedule 40, Type E or S, Grade B.

2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
Forced-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.

2.3 PIPING SPECIALTIES

A. Metallic Flexible 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.
4. End Connections: Socket, flanged, or threaded end to match connected piping.
5. Maximum Length: 30 inches
6. Swivel end, 50-psig maximum operating pressure.

2.4 JOINING MATERIALS

A. Joint Compound and Tape for Threaded Joints: Suitable for fuel.

2.5 SPECIALTY VALVES

A. Emergency Shutoff Valves:

1. 10BFP5726 Emergency Valve, Double Poppet 1 1/2" Female OPW, or approved equal
2. Double poppet valve.
3. Body: cast iron
4. Disc: M-19
5. Stem: Copper-nickel-chrome-plated brass
6. Poppet spring: Stainless steel
7. Seal: M-19 O-ring
8. Packing Nut: Brass, Teflon®-coated
9. Inlet and outlet thread: 1 1/2"
10. Thermal Relief Valve; Relieves pressure over 25 psi caused by thermal expansion

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and other conditions affecting performance of fuel piping.

B. Examine installation of fuel-handling and storage equipment to verify actual locations of piping connections before installing fuel piping.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PREPARATION

A. Close equipment shutoff valves before turning off fuel to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 OUTDOOR PIPING INSTALLATION

A. Steel Piping:

B. Install double-wall fiberglass pipe at a minimum slope of 1 percent downward toward fuel storage tank sump.

C. Install vent pipe at a minimum of 2' min. above roofline at location indicated on drawings and per OCC rules.

D. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.

E. Install metal pipes and tubes, fittings, valves, and flexible connectors, if used, at piping connections to UST.

F. Install fittings for changes in direction in rigid pipe.

G. Install system components with pressure rating equal to or greater than system operating pressure.
3.5 VALVE INSTALLATION
   A. Install manual fuel shutoff valves per OCC rules at tank.
   B. Install valves in accessible locations.
   C. Install emergency shutoff valves at dispensers.

3.6 PIPING JOINT CONSTRUCTION
   A. Ream ends of pipes and tubes and remove burrs.
   B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

3.7 INSTALLATION OF HANGERS AND SUPPORTS
   A. Install hangers for steel piping with maximum horizontal spacing and minimum rod diameters, to comply with locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
   B. Support horizontal piping within 12 inches of each fitting and coupling.
   C. Support vertical runs of steel piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.8 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION
   A. Install leak-detection and monitoring system. Install alarm panel inside of building where indicated.
   B. Connect to Veeder Root console inside building.

3.9 CONNECTIONS
   A. Where installing piping adjacent to equipment, allow space for service and maintenance.
   B. Connect piping to equipment with union. Install union between valve and equipment.
   C. Install flexible piping connectors at final connection

3.10 FIELD QUALITY CONTROL
   A. Pressure Test Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:
      1. Fuel Distribution Piping: Minimum $50 \text{ psig}$ for minimum 60 minutes.
      2. Isolate storage tanks while pressure testing piping.
B. Inspect and test fuel piping according to Oklahoma Corporation Commission Rules Chapter 26.

C. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.

D. Test and adjust controls and safety. Replace damaged and malfunctioning controls and equipment.

E. Bleed air from fuel piping using manual air vents.

F. Fuel piping and equipment will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.11 OUTDOOR PIPING SCHEDULE

A. Aboveground fuel piping shall be one of the following:

1. 2" stainless steel pipe, steel or malleable-iron threaded fittings, and threaded joints.

END OF SECTION
SECTION 231123
FACILITY NATURAL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Concrete bases.

1.3 DEFINITIONS

A. 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, crawlspace, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.
2. Service Regulators: 65 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: Not more than 2 psig.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:
1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.

B. Shop Drawings: For facility natural-gas 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.

1. Shop Drawing Scale: 1/4 inch per foot.
2. Detail mounting, supports, and valve arrangements for pressure regulator assembly.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Welding certificates.

E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

C. 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.
1.9 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.

B. 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.

C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.

D. Protect stored PE pipes and valves from direct sunlight.

1.10 PROJECT CONDITIONS

A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.

B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.11 COORDINATION

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

4. 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:

   b. End Connections: Threaded or butt welding to match pipe.
c. Lapped Face: Not permitted underground.
e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
   a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

6. Mechanical Couplings:
   a. Steel flanges and tube with epoxy finish.
   b. Buna-nitrile seals.
   c. Steel bolts, washers, and nuts.
   d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
   e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

   b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
   c. Aboveground Portion: PE transition fitting.
   d. Outlet shall be threaded or flanged or suitable for welded connection.
   e. Tracer wire connection.
   f. Ultraviolet shield.
   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

   a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
   b. Outlet shall be threaded or flanged or suitable for welded connection.
   c. Bridging sleeve over mechanical coupling.
   d. Factory-connected anode.
   e. Tracer wire connection.
   f. Ultraviolet shield.
   g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

   a. Manufacturers: Subject to compliance with requirements,[provide products by one of the following:

   1) Lyall, R. W. & Company, Inc.
   2) Mueller Co.; Gas Products Div.
   3) Perfection Corporation; a subsidiary of American Meter Company.
b. PE body with molded-in, stainless-steel support ring.
c. Buna-nitrile seals.
d. Acetal collets.
e. Electro-zinc-plated steel stiffener.

10. Plastic Mechanical Couplings, NPS 2 and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Lyall, R. W. & Company, Inc.
2) Mueller Co.; Gas Products Div.
3) Perfection Corporation; a subsidiary of American Meter Company.

b. Fiber-reinforced plastic body.
c. PE body tube.
d. Buna-nitrile seals.
e. Acetal collets.
f. Stainless-steel bolts, nuts, and washers.

11. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1) Dresser Piping Specialties; Division of Dresser, Inc.
2) Smith-Blair, Inc.

b. Steel flanges and tube with epoxy finish.
c. Buna-nitrile seals.
d. Steel bolts, washers, and nuts.
e. Factory-installed anode for steel-body couplings installed underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
8. Maximum Length: 72 inches

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

F. 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.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.


C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.
2.4 MANUAL GAS SHUTOFF VALVES

A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.

B. General Requirements for Metallic Valves, NPS and Smaller: Comply with ASME B16.33.
   1. CWP Rating: 125 psig.
   3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
   5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
   6. Service Mark: Valves 1-1/4 inche to NPS 2 shall have initials "WOG" permanently marked on valve body.

C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
   1. CWP Rating: 125 psig.
   2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
   4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
   2. Ball: Chrome-plated brass.
   3. Stem: Bronze; blowout proof.
   4. Seats: Reinforced TFE; blowout proof.
   5. Packing: Separate packnut with adjustable-stem packing threaded ends.
   7. CWP Rating: 600 psig.
   8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

E. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
   2. Ball: Chrome-plated bronze.
   3. Stem: Bronze; blowout proof.
   4. Seats: Reinforced TFE; blowout proof.
   5. Packing: Threaded-body packnut design with adjustable-stem packing.
   7. CWP Rating: 600 psig.
   8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

F. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.

2. Ball: Chrome-plated bronze.
3. Stem: Bronze; blowout proof.
4. Seats: Reinforced TFE.
5. Packing: Threaded-body packnut design with adjustable-stem packing.
7. CWP Rating: 600 psig.
8. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 100 psig.


1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.

   2. Springs: Zinc-plated steel; interchangeable.
   7. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

2.6 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:
   1. Description:
      c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
   1. Description:
      b. Factory-fabricated, bolted, companion-flange assembly.
      d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
   1. Description:
      a. Nonconducting materials for field assembly of companion flanges.
      b. Pressure Rating: 150 psig
      c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
  e. Washers: Phenolic with steel backing washers.

2.7 LABELING AND IDENTIFYING

A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils 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 deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION


B. Install underground, natural-gas piping buried at least 36 inches below finished grade.

   1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.

C. Install underground, PE, natural-gas piping according to ASTM D 2774.

D. Steel Piping with Protective Coating:

   1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.

   2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
3. Replace pipe having damaged PE coating with new pipe.

E. Install fittings for changes in direction and branch connections.

F. Install pressure gage downstream from each service regulator.

3.4 INDOOR PIPING INSTALLATION


B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. 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.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. 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.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Verify final equipment locations for roughing-in.

L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

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O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.

3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.

4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

   a. Exception: Tubing passing through partitions or walls does not require striker barriers.

5. Prohibited Locations:

   a. Do not install natural-gas 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 natural-gas piping in solid walls or partitions.

Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

R. Connect branch piping from top or side of horizontal piping.

S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

T. Do not use natural-gas piping as grounding electrode.

U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

V. Install pressure gage downstream from each line regulator.

W. Install sleeves for piping penetrations of walls, ceilings, and floors.

X. Install sleeve seals for piping penetrations of concrete walls and slabs.

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.5 SERVICE-METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground on concrete bases.
B. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.

C. Install strainer on inlet of service-pressure regulator and meter set.

D. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.

E. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.

F. Install service meters downstream from pressure regulators.

G. Install metal bollards to protect meter assemblies. Comply with requirements in Section 055000 "Metal Fabrications" for pipe bollards.

3.6 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.

B. Install underground valves with valve boxes.

C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

D. Install earthquake valves aboveground outside buildings according to listing.

E. Install anode for metallic valves in underground PE piping.

3.7 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:
   1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
   2. Cut threads full and clean using sharp dies.
   3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
   4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
   5. 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.

D. Welded Joints:
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
   1. Plain-End Pipe and Fittings: Use butt fusion.
   2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.8 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
   1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
   2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
   4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
   5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.9 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

A. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.
3.11 PAINTING

A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.

B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Alkyd System: MPI EXT 5.1D.
   c. Topcoat: Exterior alkyd enamel flat.
   d. Color: Gray.

C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.

1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
   a. Prime Coat: Alkyd anticorrosive or Quick-drying alkyd metal primer.
   c. Topcoat: Interior latex flat.
   d. Color: black.

2. Alkyd System: MPI INT 5.1E.
   a. Prime Coat: Alkyd anticorrosive or Quick-drying alkyd metal primer.
   c. Topcoat: Interior alkyd flat.
   d. Color: black.

D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 FIELD QUALITY CONTROL

A. Perform Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.

B. Natural-gas piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.
3.13 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain earthquake valves.

3.14 PIPING SCHEDULE

A. See Drawings.

3.15 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility’s gas mains and listed by an NRTL.

B. Underground:
   1. PE valves.
   2. NPS 2 and Smaller: Bronze plug valves.
   3. NPS 2-1/2 and Larger: Cast-iron, lubricated plug valves.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
   1. One-piece, bronze ball valve with bronze trim.

B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.
   3. Cast-iron, nonlubricated plug valve.

C. Distribution piping valves for pipe sizes NPS 2 and smaller shall be the following:
   1. One-piece, bronze ball valve with bronze trim.

D. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:
   1. Two-piece, full-port, bronze ball valves with bronze trim.
   2. Bronze plug valve.

E. Valves in branch piping for single appliance shall be the following:
   1. One-piece, bronze ball valve with bronze trim.

END OF SECTION
SECTION 231213
FACILITY FUEL PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Submersible fuel storage tank pumps.

1.3 DEFINITIONS

A. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, and dimensions of individual components and profiles.
   2. Include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For fuel pumps.
   1. Include construction details and dimensions of individual components for fuel pumps.
   2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   3. Scale: drawings must be submitted to a scale.

C. Delegated-Design Submittal: For fuel pumps.
   1. Detail fabrication and assembly of anchors and seismic restraints.
   2. Design Calculations: Calculate requirements for selecting seismic restraints.
   3. Detail fabrication and assembly of hangers, supports, and attachments of the same to building structure.
1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified professional engineer.

B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel pumps and fuel maintenance systems to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. 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.

B. Listed and labeled for fuel service acceptable to OCC.

2.2 SUBMERSIBLE FUEL STORAGE TANK PUMPS

A. Veeder-Root / Red Jacket Pumps, Simsbury, CT, 800-873-3313, veeder.com/us/

1. Model No. P200U13RJ2; Part No. 410142-002
   a. With floating suction.
2. Sump pump to pull samples from UST for testing.
3. Other manufacturers must be submitted for approval prior to bid.

B. Description: Comply with UL 79, UL 87, and UL 343.

1. Impeller: Turbine.
2. Housing and Volute: Cast iron.
4. Seals: Mechanical.
5. Shaft: Polished steel.
6. Suspension Piping: Telescoping to accommodate tank diameter and depth of bury.
8. Pressure Relief: Built in.
9. Discharge Check Valve: Built in.
C. Controls: Pump controller panel complying with UL 353 and UL 508C and with interlock and terminals for connections to fuel equipment.

1. Model No. 880-041-5 Standard Control Box, or approved equal

D. Capacities and Characteristics:

1. Motor Horsepower: 2 HP
2. Electrical Characteristics:
   a. Volts: 208/240
   b. Hertz: 60.

2.3 MECHANICAL LINE LEAK DETECTION

A. Red Jacket FX1DV Leak Detector
   1. Part No. 1160585

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for fuel pumps to verify actual locations of pump connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off fuel to premises or piping section.

B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.3 FUEL PUMP INSTALLATION

A. Submersible Pumps:
   
   Thread pump into 4" NPT opening on tank top.

B. Install two-piece, full-port ball valves at discharge of pumps.

C. Install mechanical leak-detector valves at pump discharge.
3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Fuel pumps will be considered defective if they do not pass tests and inspections.

3.5 DEMONSTRATION

A. Train owner's maintenance personnel to adjust, operate, and maintain fuel pumps.

END OF SECTION
SECTION 231313
FACILITY UNDERGROUND FUEL STORAGE TANKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Steel fuel USTs.
2. Liquid-level gage systems.
3. Leak-detection systems.

1.3 DEFINITIONS

A. UST: Underground storage tank.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Leak-detection and monitoring system.

B. Shop Drawings: For underground fuel storage tanks.

1. Include plans, elevations, sections, and ballast pads and anchors, and lifting or supporting points.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.5 INFORMATIONAL SUBMITTALS

A. Site Survey: Plans, drawn to scale, on which underground fuel storage tanks are shown and coordinated with other services and utilities.
B. Field quality-control reports.

C. Sample Warranty: For special warranty.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: trained and UST certified installer by the state of Oklahoma.

1. Fuel system installer must be located in and provide service operations within the Tulsa Metro area to provide emergency response as needed.

B. Underground Fuel Storage Tanks: Comply with requirements of the Oklahoma Corporation Commission (OCC) and of state and local authorities having jurisdiction, including recording fuel storage tanks.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Lift and support fuel storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

1.8 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of fuel storage tanks that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:
   a. Failures include, but are not limited to, the following when used for storage of fuel
      1) Structural failures including cracking, breakup, and collapse.
      2) Corrosion failure including external and internal corrosion of steel tanks.
   b. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 STEEL, FUEL UST

A. Hall Tank Co., P.O. Drawer 5787, North Little Rock, AR 72119, 800-322-4255

1. Model No. ACT-100
2. Other manufacturers must be submitted for approval prior to bid.

B. Description: UL 58, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and interstitial space.
C. 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:
   1. Depth of Bury: install according to tank manufacturer's recommendations.
   2. Install tank using deadmen anchors according to tank manufacturer recommendations.

D. Corrosion-Protection System:
   1. Interior tank lining: Two (2) coats of epoxy, Sherwin Williams Duraplate UHS.

E. Capacities and Characteristics:
   1. Capacity: 10,000 gal.
   2. Diameter: 96 inches
   3. Length: 328 inches

2.2 FUEL UST ACCESSORIES

A. Tank Manholes: bolted, flanged, and gasketed, with extension collar; for access to inside of tank.

B. Threaded pipe connection fittings on top of tank for fill, supply, vent, and gaging; in locations and of sizes indicated. Include cast-iron plugs for shipping.

C. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.

D. Lifting Lugs: For handling and installation.

E. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches above tank bottom and cut at a 45-degree angle.

F. Spill containment: OPW 1SC2100DEVR with drain – or approved equal.

G. 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.

H. 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 92 percent of tank capacity and to provide complete shutoff of filling at 95 percent of tank capacity.

2.3 LIQUID-LEVEL GAGE SYSTEM/LEAK-DETECTION AND MONITORING SYSTEM

A. ATG: Veeder Root TLS450 Plus.- Contractor to uninstall console at existing facility and reinstall at new hangar. All sensors and probes are to be new as specified.
   1. All systems must be compliant with City of Tulsa software.
   2. Sump sensors
   3. Phone and ethernet connections.
B. Controls: Electrical, operating on 110 volt.

C. Cable and Sensor System: Comply with UL 1238.
   1. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel storage tanks and fuel piping.
   2. Include fittings and devices required for testing.

2.4 MANHOLES
   A. Provide one (1) 651212WC 12” Monitor well manhole or approved equal.
   B. Provide one (1) 658012WC 8’ Monitor well manhole or approved equal.
   C. Provide one (1) 38” Round lightweight manhole 318L3800AMC Mor Bro or approved equal.

2.5 SOURCE QUALITY CONTROL
   A. Pressure test and inspect fuel storage tanks, after fabrication and before shipment per OCC requirements.

PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine roughing-in for underground fuel storage tanks to verify actual locations.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK
   A. Comply with requirements in contract documents for excavating, trenching, and backfilling.
   B. Excavate to sufficient depth for a minimum of 36 inches of earth cover from top of tank to finished grade. Allow for 6 inches of 3/8” inch washed agg base between tank and bottom of excavation. Extend excavation at least 12 inches around perimeter of tank. Allow for deadmen on agg base.
   C. Backfill excavation 3/8” inch washed agg base in a minimum of two lifts and tamp backfill lift to consolidate.
   D. Install filter mat between top of backfill material and earth fill.
3.3 FUEL UST INSTALLATION
   A. Set deadmen per ballast calculation.
   B. Set tank on fill materials and install hold-down straps.
   C. Connect piping.
   D. Install tank leak-detection and monitoring devices.
   E. Install containment sumps.
   F. Install steel USTs, hold down straps, manhole extensions, and manhole risers according to STI R913 and STI R891.

3.4 LIQUID-LEVEL GAGE SYSTEM INSTALLATION
   A. Install liquid-level gage system. Install panel inside building where indicated.

3.5 LEAK-DETECTION AND MONITORING SYSTEM INSTALLATION
   A. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.
      3. Install liquid-level gage.

3.6 FIELD QUALITY CONTROL
   A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
      1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel storage tanks per OCC.
   B. USTs will be considered defective if they do not pass tests and inspections.
   C. Prepare test and inspection reports.

END OF SECTION
SECTION 231313.1

FUELING ELECTRONIC DISPENSER

PART 1 - GENERAL

1.1 SUMMARY

A. Related Requirements:
   1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
   2. Section 231113 "Facility Fuel Piping" for all piping related to dispenser and fuel system.
   3. Section 231213 "Facility Fuel Pumps" for all pumps related to dispenser and fuel system.
   4. Section 231313 "Facility Underground Fuel Storage Tanks for UST related to dispenser and fuel system.

2.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, and dimensions of individual components and profiles.

B. Shop Drawings: For dispenser cabinet.
   1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size.

2.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 3 - PRODUCT

3.1 Product

A. Fleet non computing – Electronic register

3.2 Type

A. Jet A Fuel Garsite Dispenser Cabinet
B. Other manufacturers must be submitted for approval prior to bid,

3.3 Flowrate – capable of delivery in typical installations

A. Jet A High Flow (HF) = 30 gpm
3.4 Models
A. Garsite Jet A dispensing cabinet to include:
   1. LC M5 Meter with Veeder Root Mechanical register
   2. Schedule 10 Stainless steel piping
   3. Facet VF-22 Filter with filter monitor with differential pressure gauge.
   4. Electric rewind hose reel with 1” x 75’ aviation fuel hose
   5. OPW29S3AJ overwing fueling nozzle and nozzle clip.
   6. Fire shutoff valve in line before hose.
   7. 15 gallon product reclaim tank
   8. Fire rate stainless steel ball valves
   9. Enclosure cabinet/stainless steel/hinge flip down door at front and sides. 74” wide X 62” deep X 60” tall.
   10. Output pulsers for card system.

3.5 Unit of Measure
   A. US Gallons

3.6 Fuel Compatibility
   A. Suitable for use with Jet A fuel.

3.7 Electrical Requirements
   A. Electronics: 115/230V, 50/60Hz,1-phase

3.8 Regulatory Approvals
   A. Safety: UL or cUL approved (File# MH1941)
   B. Weights & Measures: Meter accuracy meets requirements for retail custody transfer, sealable by local officials.
      1. National Conference of Weights & Measures certified
      2. Measurement Canada (MC) certified.
   C. FCC Part 15 Compliant
   D. NYCFD approved

3.9 Warranty
   A. 12 month parts & labor standard from date of Substantial Completion.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, and drawings, apply to this Section.

1.2 SUMMARY

A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:


1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. 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.

1. Shop Drawing Scale: 1/4 inch equals 1 foot.
2. 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.
1.5 INFORMATIONAL SUBMITTALS
   A. Welding certificates.
   B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS
   A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE
   A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
   C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING
   A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION
   A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS
   A. Copper Tube: ASTM B 88, Type K or L.
   B. Wrought-Copper Fittings: ASME B16.22.
   C. Wrought-Copper Unions: ASME B16.22.
   D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
   E. Brazing Filler Metals: AWS A5.8.
   F. Flexible Connectors:
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
5. Maximum Operating Temperature: 250 deg F.

2.2 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
3. Operator: Rising stem and hand wheel.
5. End Connections: Socket, union, or flanged.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
4. End Connections: Copper spring.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and ac coil.
7. Maximum Operating Temperature: 240 deg F.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
4. End Connections: Threaded.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
7. End Connections: Socket, flare, or threaded union.

H. Straight-Type Strainers:

2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
5. Maximum Operating Temperature: 275 deg F.

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
6. Maximum Operating Temperature: 275 deg F.

J. Moisture/Liquid Indicators:

2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
5. End Connections: Socket or flare.
7. Maximum Operating Temperature: 240 deg F.

K. Replaceable-Core Filter Dryers: Comply with ARI 730.
   1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina or charcoal.

L. Permanent Filter Dryers: Comply with ARI 730.
   2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
   3. Desiccant Media: Activated alumina or charcoal.

M. Mufflers:
   2. End Connections: Socket or flare.
   4. Maximum Operating Temperature: 275 deg F.

N. Receivers: Comply with ARI 495.
   1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   2. Comply with UL 207; listed and labeled by an NRTL.
   4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
   5. End Connections: Socket or threaded.
   7. Maximum Operating Temperature: 275 deg F.

O. Liquid Accumulators: Comply with ARI 495.
   2. End Connections: Socket or threaded.
   4. Maximum Operating Temperature: 275 deg F.

2.3 REFRIGERANTS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction, Hot-Gas, and Liquid Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.

B. Suction, Hot-Gas, and Liquid Lines NPS 3-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless valves in suction and discharge lines of compressor.

B. 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.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.

E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

F. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. 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.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

G. 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.
H. 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.

I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
   1. Solenoid valves.
   2. Thermostatic expansion valves.
   3. Compressor.

J. Install filter dryers in liquid line between compressor and thermostatic expansion valve.

K. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

A. 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.

B. Install refrigerant piping according to ASHRAE 15.

C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Select system components with pressure rating equal to or greater than system operating pressure.

J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. 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 if valves or equipment requiring maintenance is concealed behind finished surfaces.

L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

M. Slope refrigerant piping as follows:
1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Liquid lines may be installed level.

N. 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.

O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

P. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

Q. Install sleeves for piping penetrations of walls, ceilings, and floors.

R. Install sleeve seals for piping penetrations of concrete walls and slabs.

S. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 PIPE JOINT CONSTRUCTION

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. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
   1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.5 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
   4. Spring hangers to support vertical runs.
   5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 1/2: Maximum span, 60 inches minimum rod size, 1/4 inch.
   2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
7. NPS 2-1/2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
8. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
9. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.

D. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. 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.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
   a. Fill system with nitrogen to the required test pressure.
   b. System shall maintain test pressure at the manifold gage throughout duration of test.
   c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
   d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION
SECTION 233113
METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round ducts and fittings.
   4. Duct liner.
   5. Hangers and supports.

1.3 PERFORMANCE REQUIREMENTS

A. 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.

B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.

B. Shop Drawings:
   1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
   2. Factory- and shop-fabricated ducts and fittings.
   3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.

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4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

A. 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:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
   
a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.
f. Perimeter moldings.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse 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."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," 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. 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 4, "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."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. 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.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse 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."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," 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. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "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."

2.3 SHEET METAL MATERIALS

A. 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.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G60.
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.

B. 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.

C. Insulation Pins and Washers:

1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

1. 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.
2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
3. Butt transverse joints without gaps, and coat joint with adhesive.
4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. 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.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. 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:
   a. Fan discharges.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
9. 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.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.

10. 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.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

D. 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.

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports:

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. 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.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.
E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. 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.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.

3.2 DUCT SEALING

A. 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."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.3 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

C. Hanger Spacing: Comply with SMACNA’s “HVAC Duct Construction Standards - Metal and Flexible,” Table 5-1, “Rectangular Duct Hangers Minimum Size,” and Table 5-2, “Minimum Hanger Sizes for Round Duct,” for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. 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.

F. 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.

3.4 CONNECTIONS

A. Make connections to equipment with flexible connectors.

B. Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 PAINTING

A. 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 Section 099113 “Exterior Painting” and Section 099123 “Interior Painting.”

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. 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."
a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. 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.

2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.

3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. 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.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).

2. 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.

3. 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.


5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.


7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.

2. 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.

3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. 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.
5. 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.
6. Provide drainage and cleanup for wash-down procedures.
7. 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.

3.8 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.9 DUCT SCHEDULE

A. Duct materials and liners: See Drawings.

B. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

   a. Velocity 1000 fpm or Lower:

      1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      2) Mitered Type RE 4 without vanes.

   b. Velocity 1000 to 1500 fpm:

      1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      2) Radius Type RE 3 with minimum 0.5 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 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

   c. Velocity 1500 fpm:

      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 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
a. 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.

   1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
   2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
   3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.

C. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: Spin in.

2. Round: Comply with SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

   a. Velocity 1000 fpm or Lower: 90-degree tap.
   b. Velocity 1000 to 1500 fpm: Conical tap.
   c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION
SECTION 233300
AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   2. Flexible ducts.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION


B. 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.

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
   1. Standard leakage rating.
   2. Suitable for horizontal or vertical applications.
   3. Frames:
      a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel.
      b. Mitered and welded corners.
      c. Flanges for attaching to walls and flangeless frames for installing in ducts.
   4. Blades:
      a. Multiple or single blade.
      b. Parallel- or opposed-blade design.
      c. Stiffen damper blades for stability.
      d. Galvanized-steel, 0.064 inch thick.

2.3 FLEXIBLE DUCTS

A. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized polyester vapor-barrier film.

1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
3. Temperature Range: Minus 10 to plus 160 deg F.
5. Maximum length: 7'.

PART 3 - EXECUTION

3.1 INSTALLATION

A. 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.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts.

C. 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.

1. Install steel volume dampers in steel ducts.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Connect flexible ducts to metal ducts with adhesive plus strap.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

END OF SECTION
SECTION 233713
DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

A. See drawings

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. 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 Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.
END OF SECTION
SECTION 237413
PACKAGED, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, outdoor, central-station air-handling units (rooftop units) with the following components and accessories:

1. Direct-expansion cooling.
2. Hot-gas reheat.
4. Economizer outdoor- and return-air damper section.
5. Integral, space temperature controls.
6. Roof rails.

1.3 DEFINITIONS

A. DDC: Direct-digital controls.

B. ECM: Electrically commutated motor.

C. 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.

D. 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.

E. 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.

F. 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.

G. 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.

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"Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

H. VVT: Variable-air volume and temperature.

1.4 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans 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:

1. Structural members to which RTUs will be attached.
2. Wall openings.
3. Roof rails.

B. Field quality-control test reports.

C. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For RTUs to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for each belt-driven fan.
2. Filters: Two sets of filters for each unit.

1.8 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 203/110 and ARI 303/110 for testing and rating energy efficiencies for RTUs.
2. Comply with ARI 270 for testing and rating sound performance for RTUs.
B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

E. UL Compliance: Comply with UL 1995.

F. 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.

1.9 WARRANTY

A. 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.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Gas Furnace Heat Exchangers: Manufacturer's standard, but not less than 10 years from date of Substantial Completion.
3. Warranty Period for Solid-State Ignition Modules: Manufacturer's standard, but not less than three years from date of Substantial Completion.
4. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 RTU'S

A. See RTU schedule on drawings.

1. Products are to match basis of design (as indicated on drawings).
2. All other manufacturers must be submitted in accordance with Specification 012500 – Substitution Procedures

2.2 ROOF RAILS

A. Materials: Galvanized steel with corrosion-protection coating, and factory-installed wood nailer;
complying with NRCA standards.

B. Rail Height: 12 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where RTUs will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Roof Rail: Install on roof structure or concrete base, level and secure. Install RTUs on rails and coordinate wall penetrations. Secure RTUs to roof rail, and secure roof rail base to roof framing or concrete base with anchor bolts.

3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Install piping adjacent to RTUs to allow service and maintenance.

1. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." 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.

C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Connect supply and return ducts to RTUs with flexible duct connectors.

3.4 FIELD QUALITY CONTROL

A. 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.

B. Perform tests and inspections and prepare test reports.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

C. Tests and Inspections:
   1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
   2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:
   1. Inspect for visible damage to unit casing.
   2. Inspect for visible damage to furnace combustion chamber.
   3. Inspect for visible damage to compressor, coils, and fans.
   4. Inspect internal insulation.
   5. Verify that labels are clearly visible.
   6. Verify that clearances have been provided for servicing.
   7. Verify that controls are connected and operable.
   8. Verify that filters are installed.
   9. Clean condenser coil and inspect for construction debris.
  10. Clean furnace flue and inspect for construction debris.
  11. Connect and purge gas line.
  12. Remove packing from vibration isolators.
  13. Inspect operation of barometric relief dampers.
  14. Verify lubrication on fan and motor bearings.
  15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
  16. Adjust fan belts to proper alignment and tension.
  17. Start unit according to manufacturer's written instructions.

   a. Start refrigeration system.
   b. Do not operate below recommended low-ambient temperature.
   c. Complete startup sheets and attach copy with Contractor's startup report.

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18. Inspect and record performance of interlocks and protective devices; verify sequences.
19. Operate unit for an initial period as recommended or required by manufacturer.
20. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
   a. Measure gas pressure on manifold.
   b. Inspect operation of power vents.
   c. Measure combustion-air temperature at inlet to combustion chamber.
   d. Measure flue-gas temperature at furnace discharge.
   e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
   f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
22. Adjust and inspect high-temperature limits.
23. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
   a. Coil leaving-air, dry- and wet-bulb temperatures.
   b. Coil entering-air, dry- and wet-bulb temperatures.
   c. Outdoor-air, dry-bulb temperature.
   d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
   a. Supply-air volume.
   b. Return-air volume.
   c. Relief-air volume.
   d. Outdoor-air intake volume.
27. Simulate maximum cooling demand and inspect the following:
   a. Compressor refrigerant suction and hot-gas pressures.
   b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
28. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
   b. Low-temperature safety operation.
   c. Filter high-pressure differential alarm.
   d. Economizer to minimum outdoor-air changeover.
   e. Relief-air fan operation.
   f. Smoke and firestat alarms.
29. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.6 CLEANING AND ADJUSTING

A. 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.

B. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain RTUs.

END OF SECTION
SECTION 238129
VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes complete VRF HVAC system(s) including, but not limited to, the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, exposed, wall-mounted units.
2. Outdoor, air-source, heat-pump units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.

B. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Warranty: Special warranty specified in this Section.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.
1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Nationally recognized manufacturer of VRF HVAC systems and products.
2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of 5 years within time of bid.
3. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
4. Having full-time in-house employees for the following:
   a. Product research and development.
   b. Product and application engineering.
   c. Product manufacturing, testing, and quality control.
   d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
   e. Owner training.

B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.

C. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store products in a clean and dry place.

B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.

C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.

D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.

   1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
   2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remover coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.

E. Replace installed products damaged during construction.

1.8 WARRANTY

A. 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:
1. Warranty Period, Commencing on Date of Substantial Completion:
   a. Refrigeration Compressors: 5 years
   b. Parts: 1 year
   c. Labor: 1 year

PART 2 - PRODUCTS

2.1 INDOOR, EXPOSED, WALL-MOUNTED UNITS

A. Cabinet:
   1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
   2. Mounting: Manufacturer-designed provisions for field installation.
   3. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

B. DX Coil Assembly:
   1. Coil Casing: Aluminum, galvanized, or stainless steel.
   2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
   3. Coil Tubes: Copper, of diameter and thickness required by performance.
   4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
   5. Unit Internal Tubing: Copper tubing with brazed joints.
   6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
   7. Field Piping Connections: Manufacturer's standard.
   8. Factory Charge: Dehydrated air or nitrogen.
   9. Testing: Factory pressure tested and verified to be without leaks.

C. Drain Assembly:
   1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
      a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
   3. Field Piping Connection: Non-ferrous material.

D. Fan and Motor Assembly:
   1. Fan(s):
      a. Direct-drive arrangement.
      b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
      c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
d. Wheels statically and dynamically balanced.

2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
5. Vibration Control: Integral isolation to dampen vibration transmission.

E. Filter Assembly:
1. Access: Front, to accommodate filter replacement without the need for tools.

F. Grille Assembly: Manufacturer's standard discharge grille mounted in front face of unit cabinet.

G. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.

H. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.

I. Unit Electrical:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in [metal] raceways to comply with NFPA 70.

2.2 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.

1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
3. All units installed shall be from the same product development generation.
B. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.
2. Mounting: Manufacturer-designed provisions for field installation.
3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. Compressor and Motor Assembly:

1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
2. Protection: Integral protection against the following:
   a. High refrigerant pressure.
   b. Low oil level.
   c. High oil temperature.
   d. Thermal and overload.
   e. Voltage fluctuations.
   f. Phase failure and phase reversal.
   g. Short cycling.
3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
5. Oil management system to ensure safe and proper lubrication over entire operating range.
6. Crankcase heaters with integral control to maintain safe operating temperature.
7. Fusible plug.

D. Condenser Coil Assembly:

1. Plate Fin Coils:
   a. Casing: Aluminum, galvanized, or stainless steel.
   b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
   c. Tubes: Copper, of diameter and thickness required by performance.
2. Coating: Corrosion resistant.
3. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.

E. Condenser Fan and Motor Assembly:

1. Fan(s): Propeller type.
   a. Direct-drive arrangement.
   b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
   c. Statically and dynamically balanced.
2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
5. Speed Settings and Control: Variable speed with a speed range of least [75] <Insert number> percent.

F. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
4. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

G. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

H. Unit Hardware: Zinc-plated steel, or stainless steel.

I. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.3 SYSTEM CONTROLS

A. Wired Controllers for Indoor Units:

1. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
2. On/Off: Turns indoor unit on or off.
3. Hold: Hold operation settings until hold is released.
5. Temperature Display: 1-degree increments.
6. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between 68-78
7. Relative Humidity Display: 1 percent increments.
8. Relative Humidity Set-Point: Adjustable in 1 percent increments between 40-70.
9. Fan Speed Setting: Select between available options furnished with the unit.
10. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
11. Seven-day programmable operating schedule with up to four events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
12. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
13. Service Notification Display: "Filter".
15. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
16. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
17. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

PART 3 - EXECUTION

3.1 INSTALLATION OF INDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.

D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.

E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.

F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.

G. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.

H. Attachment: Install hardware for proper attachment to supported equipment.

3.2 INSTALLATION OF OUTDOOR UNITS

A. Install units to be level and plumb while providing a neat and finished appearance.

B. Install outdoor units on support structures indicated on Drawings.
C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."

1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Grouting: Place grout under equipment supports and make bearing surface smooth.

D. Rooftop Installations: Install outdoor units on equipment supports. Anchor units to supports with removable, stainless-steel fasteners.

3.3 INSTALLATION OF SYSTEM CONTROL CABLE

A. Comply with NECA 1.

B. Installation Method:

1. Install cables in raceways except as follows:
   a. Within equipment and associated control enclosures.
   b. In accessible ceiling spaces where open cable installation method may be used.
   c. In gypsum board partitions where cable may be enclosed within wall cavity.

2. Conceal raceway and cables except in unfinished spaces.

C. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.4 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. 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. Perform the following tests and inspections with the assistance of manufacturer's service representative:
1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Products will be considered defective if they do not pass tests and inspections.

3.6 PROTECTION

A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.

B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.

C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.

D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
SECTION 260519
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Aluminum building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Fire-alarm wire and cable.
5. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.
B. Product Schedule: Indicate type, use, location, and termination locations.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Encore Wire Corporation.
2. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 and ASTM B496 for stranded conductors.

E. Conductor Insulation:

1. Type RHH and Type RHW-2: Comply with UL 44.
2. Type THHN and Type THWN-2: Comply with UL 83.
3. Type XHHW-2: Comply with UL 44.

2.2 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Encore Wire Corporation.
2. Southwire Company.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

E. Conductor Insulation:

1. Type RHH and Type RHW-2: Comply with UL 44.
2. Type THHN and Type THWN-2: Comply with UL 83.
3. Type XHHW-2: Comply with UL 44.

2.3 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Encore Wire Corporation.
2. Southwire Company.
C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits:


E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

H. Armor: Aluminum, interlocked.

I. Jacket: PVC applied over armor.

2.4 FIRE-ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Allied Wire & Cable Inc.
2. CommScope, Inc.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG.

1. 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 two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. 3M Electrical Products.
   2. NSi Industries LLC.

C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
   1. Material: Copper.
   2. Type: Two hole with long barrels.
   3. Termination: Crimp.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders:
   1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
   2. Copper for feeders smaller than No. 4 AWG; copper for feeders No. 4 AWG and larger.
      Conductors shall be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits:
   1. Copper, Solid for No. 12 AWG and smaller; stranded for No. 10 AWG and larger.


3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.
B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.

H. Use of MC cable is strictly limited to locations approved in writing, in advance by engineer of record. All other installations shall be wire in raceway as listed above.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring in metal pathway according to Section 280528 "Pathways for Electronic Safety and Security."

1. Install plenum cable in environmental airspaces, including plenum ceilings.
2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system shall be installed in a dedicated pathway system.
   
a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.

3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is permitted.
4. Signaling Line Circuits: Power-limited fire-alarm cables shall not be installed in the same cable or pathway as signaling line circuits.

C. 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 fire-alarm 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. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

E. 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.

F. 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 receipt or transmission of signals from other floors or zones.

G. Wiring to Remote Alarm Transmitting Device: 1-inch 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.

3.5 CONNECTIONS

A. 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-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
   
   1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

D. Comply with requirements in Section 284621.11 "Addressable Fire-Alarm Systems" for connecting, terminating, and identifying wires and cables.
3.6 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

END OF SECTION
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SECTION 260523
CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backboards.
2. Category 5e balanced twisted pair cable.
3. Balanced twisted pair cabling hardware.
4. RS-485 cabling.
5. Low-voltage control cabling.

1.2 DEFINITIONS

A. 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.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency, RCDD, layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Accredited by NETA.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. 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.

B. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

D. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

E. RoHS compliant.

2.2 BACKBOARDS

A. Description: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

B. Painting: Paint plywood on all sides and edges with flat black alkyd paint. Comply with requirements in Section 099123 "Interior Painting."

2.3 CATEGORY 5e BALANCED TWISTED PAIR CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 5e cable at frequencies up to 100 MHz.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Belden CDT Networking Division/NORDX.
2. Berk-Tek Leviton; a Nexans/Leviton alliance.
3. CommScope, Inc.

C. Standard: Comply with ICEA S-90-661, NEMA WC 63.1, and TIA-568-C.2 for Category 5e cables.

D. Conductors: 100-ohm, 24 AWG solid copper.
E. Shielding/Screening: Unshielded twisted pairs (UTP).

F. Cable Rating: Plenum.

G. Jacket: thermoplastic.

2.4 BALANCED TWISTED PAIR CABLE HARDWARE

A. Description: Hardware designed to connect, splice, and terminate balanced twisted pair copper communications cable.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Belden CDT Networking Division/NORDX.
2. Berk-Tek Leviton; a Nexans/Leviton alliance.
3. CommScope, Inc.

C. General Requirements for Balanced Twisted Pair Cable Hardware:

1. Comply with the performance requirements of Category 6.
2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
3. Cables shall be terminated with connecting hardware of same category or higher.

D. Source Limitations: Obtain balanced twisted pair cable hardware from single source from single manufacturer.

E. Connecting Blocks: 110-style IDC for Category 6. 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.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

G. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.

1. Features:
   a. Universal T568A and T568B wiring labels.
   b. Labeling areas adjacent to conductors.
   c. Replaceable connectors.
   d. 24 or 48 ports.

2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
3. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.
H. Patch Cords: Factory-made, four-pair cables in 48-inchlengths; terminated with an eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

I. Plugs and Plug Assemblies:

1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Comply with IEC 60603-7-1, IEC 60603-7-2, IEC 60603-7-3, IEC 60603-7-4, and IEC 60603-7.5.
3. Marked to indicate transmission performance.

J. Jacks and Jack Assemblies:

1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair 100-ohm unshielded or shielded balanced twisted pair cable.
2. Designed to snap-in to a patch panel or faceplate.
3. Standards.
   a. Category 5e, unshielded balanced twisted pair cable shall comply with IEC 60603-7-2.
   b. Category 5e, shielded balanced twisted pair cable shall comply with IEC 60603-7-3.
   c. Category 6, unshielded balanced twisted pair cable shall comply with IEC 60603-7-4.
   d. Category 6, shielded balanced twisted pair cable shall comply with IEC 60603-7.5.
   e. Category 6a, unshielded balanced twisted pair cable shall comply with IEC 60603-7-41.
   f. Category 6a, shielded balanced twisted pair cable shall comply with IEC 60603-7.51.
4. Marked to indicate transmission performance.

K. Faceplate:

1. Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. Eight port, vertical double gang faceplates designed to mount to double gang wall boxes.
4. Metal Faceplate: Stainless steel, complying with requirements in Section 262726 "Wiring Devices."
5. For use with snap-in jacks accommodating any combination of balanced twisted pair, optical fiber, and coaxial work area cords.
   a. Flush mounting jacks, positioning the cord at a 45-degree angle.

L. Legend:

1. Machine printed, in the field, using adhesive-tape label.
2. Snap-in, clear-label covers and machine-printed paper inserts.
2.5 TWIN-AXIAL DATA HIGHWAY CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.
   1. Paired, pairs, No. 20 AWG, stranded (7x28) tinned-copper conductors.
   2. Plastic insulation.
   3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
   5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.

2.6 RS-232 CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Belden Inc.
   2. Southwire Company.

B. PVC-Jacketed, TIA 232-F:
   1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
   2. Polypropylene insulation.
   3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
   4. PVC jacket.
   5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
   6. NFPA 70 Type: Type CM.
   7. Flame Resistance: Comply with UL 1581.

C. Plenum-Type, TIA 232-F:
   1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
   2. PE insulation.
   3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
   4. Fluorinated ethylene propylene jacket.
   5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

2.7 RS-485 CABLE

A. Plenum-Rated Cable: NFPA 70, Type CMP.
   1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
   2. Fluorinated ethylene propylene insulation.
   3. Unshielded.
4. Fluorinated ethylene propylene jacket.

2.8 LOW-VOLTAGE CONTROL CABLE

A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
   1. Multi-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.

2.9 CONTROL-CIRCUIT CONDUCTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Encore Wire Corporation.
   2. Southwire Company.

B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

C. Class 2 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.
   1. Smoke control signaling and control circuits.

2.10 FIRE-ALARM WIRE AND CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   1. Superior Essex Inc.
   2. West Penn Wire.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG.
1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification Cl, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.

D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.

1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire-alarm and cable tray installation, plenum rated.

2.11 SOURCE QUALITY CONTROL

A. Factory test balanced twisted pair cables according to TIA-568-C.2.

B. Cable will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Test cables on receipt at Project site.

1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
2. Outlet boxes shall be no smaller than 4 inches square by 2-1/8 inches deep with extension ring sized to bring edge of ring to within 1/8 inch of the finished wall surface.
3. Flexible metal conduit shall not be used.

B. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

D. Raceway Installation in Equipment Rooms:
1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard if entering the room from overhead.
4. Extend conduits 12 inches above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

E. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable between termination, tap, or junction points.
5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
11. Support: Do not allow cables to lay on removable ceiling tiles.
12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals. Do not bend cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
15. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

C. Balanced Twisted Pair Cable Installation:

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2. Install termination hardware as specified in Section 271513 "Communications Copper Horizontal Cabling" unless otherwise indicated.
3. Do not untwist UTP cables more than 1/2 inch at the point of termination to maintain cable geometry.

D. Installation of Control-Circuit Conductors:

1. Install wiring in raceways. Comply with requirements specified in Section 260533 "Raceways and Boxes for Electrical Systems."

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
3. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Below each feed point, neatly coil a minimum of 72 inches of cable in a coil not less than 12 inches in diameter.

3.4 REMOVAL OF CONDUCTORS AND CABLES

A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified with a tag for future use.

3.5 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.6 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping."

B. Comply with TIA-569-D, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping" Chapter.
3.7 GROUNDING

A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.

B. For low-voltage control wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.

C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

   1. Visually inspect 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-568-C.1.

   2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION
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SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes grounding and bonding systems and equipment.

B. Section includes grounding and bonding systems and equipment, plus the following special applications:
   1. Underground distribution grounding.
   2. Ground bonding common with lightning protection system.
   3. Foundation steel electrodes.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article.

B. Qualification Data: For testing agency and testing agency's field supervisor.

C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
   a. Test wells.
   b. Ground rods.
   c. Ground rings.
   d. Grounding arrangements and connections for separately derived systems.

2. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, and grounding connections for separately derived systems based on NETA MTS and NFPA 70B.
a. Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
b. Include recommended testing intervals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. 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.

B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

2. Hubbell Incorporated (Burnsdv).
3. ILSCO.

2.3 CONDUCTORS

A. Insulated Conductors: Copper or tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.
2.4 CONNECTORS

A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

D. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

E. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.

F. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

G. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

H. Conduit Hubs: Mechanical type, terminal with threaded hub.

I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt or socket set screw.

J. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.

K. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.

L. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.

M. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.

N. Straps: Solid copper, copper lugs. Rated for 600 A.

O. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.

P. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.

Q. Water Pipe Clamps:

1. Mechanical type, two pieces with stainless-steel bolts.
   a. Material: Tin-plated aluminum or Die-cast zinc alloy.
   b. Listed for direct burial.

2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.
2.5 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet.

B. Ground Plates: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
   1. Bury at least 30 inches below grade.

C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
   2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

D. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 GROUNDING AT THE SERVICE

A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.
B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches 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 above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.

C. 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 according to written instructions by manufacturer of splicing and termination kits.

D. 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 from the foundation.

3.5 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. 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.

C. 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.

D. 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.
E. 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.

3.6 FENCE GROUNDING

A. Fence Grounding: Install at maximum intervals of [1500 feet] except as follows:

1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [750 feet].
   a. Gates and Other Fence Openings: Ground fence on each side of opening.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.

3.7 INSTALLATION

A. 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.

B. Ground Bonding Common 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.

C. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.

D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:
1. 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; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by 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.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections with the assistance of a factory-authorized service representative.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.

2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.

   a. Measure ground resistance no fewer 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.

   b. Perform tests by fall-of-potential method according to IEEE 81.

4. 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.

C. Grounding system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION
SECTION 260529
HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

B. Related Requirements:

1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

2. Slotted support systems.
3. Equipment supports.
4. 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. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, and coordinated with each other, using input from installers of the items involved.
B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.

C. Welding certificates.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Atkore International (Unistrut).
   b. Eaton (B-line).
   c. nVent (CADDY).

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel, Stainless steel Type 304, or Stainless steel Type 316.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored 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 made of malleable iron.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. 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.
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   1) Hilti, Inc.
   2) ITW Ramset/Red Head; Illinois Tool Works, Inc.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   1) Eaton (B-line).
   2) Hilti, Inc.
   3) ITW Ramset/Red Head; Illinois Tool Works, Inc.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
6. Toggle Bolts: All-steel springhead type.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 102.
4. NECA 105.
5. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.
3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.

C. 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.

D. 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:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. 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 thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. 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 comply with seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

END OF SECTION
SECTION 260533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
7. Handholes and boxes for exterior underground cabling.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
2. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
3. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. ABB (Electrification Products Division).

2. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. ARC: Comply with ANSI C80.5 and UL 6A.
5. IMC: Comply with ANSI C80.6 and UL 1242.
6. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
   a. Comply with NEMA RN 1.
   b. Coating Thickness: 0.040 inch, minimum.

7. EMT: Comply with ANSI C80.3 and UL 797.
8. FMC: Comply with UL 1; zinc-coated steel or aluminum.
9. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings: Comply with NEMA FB 1 and UL 514B.

1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
4. Fittings for EMT:
   a. Material: Steel.
   b. Type: Compression.

5. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
6. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.
2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Cantex Inc.
   b. Champion Fiberglass, Inc.
   c. Hubbell Incorporated (Raco Taymac Bell).
   d. Kraloy Fittings.
   e. Lamson & Sessions.

B. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1. ENT: Comply with NEMA TC 13 and UL 1653.
2. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
3. LFNC: Comply with UL 1660.

C. Nonmetallic Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Cantex Inc.
   b. Champion Fiberglass, Inc.
   c. Hubbell Incorporated (Raco Taymac Bell).
   d. Kraloy Fittings.
   e. Lamson & Sessions.

2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
4. Fittings for LFNC: Comply with UL 514B.
5. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB (Electrification Products Division).
2. Eaton (B-line).
3. Hubbell Incorporated (Wiegmann).
4. nVent (Hoffman).
5. Schneider Electric USA (Square D).
B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1, Type 3R, Type 4X, or Type 12 as required by installation use/location unless otherwise indicated, and sized according to NFPA 70.

1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Fittings and Accessories: Include covers, 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.

2.4 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB (Electrification Products Division).
2. Eaton (B-line).
3. Hubbell Incorporated (Wiegmann).
4. nVent (Hoffman).
5. Schneider Electric USA (Square D).

B. Listing and Labeling: Nonmetallic wireways and auxiliary gutters shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.

D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.

E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.5 BOXES, ENCLOSURES, AND CABINETS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB (Electrification Products Division).
2. Eaton (Crouse-Hinds).
5. Erickson Electrical Equipment Company.
6. Hubbell Incorporated (Raco Taymac Bell).

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.

E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.

F. Metal Floor Boxes:
   2. Type: Fully adjustable.
   3. Shape: Rectangular.
   5. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Nonmetallic Floor Boxes: Nonadjustable, round.
   1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.

I. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.
   1. Listing and labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

J. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

K. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.

L. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

M. Device Box Dimensions: 4 inches square by 2-1/8 inches deep 4 inches by 2-1/8 inches by 2-1/8 inches deep.

N. Gangable boxes are prohibited.

O. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, Type 4X, or Type 12 as required by installation use/location, with continuous-hinge cover with flush latch unless otherwise indicated.
   1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
   3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
P. Cabinets:

1. NEMA 250, Type 1, Type 3R, Type 4X, or Type 12 as required by installation use/location, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANOHOLE AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. General Requirements for Handholes and Boxes:

1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Armorcast Products Company.
   b. Hubbell Incorporated (Quazite).

2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Armorcast Products Company.
   b. Hubbell Incorporated (Quazite).
2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, "ELECTRIC".
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
2. Concealed Conduit, Aboveground: GRC, IMC, or EMT.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R or Type 4X.

B. Indoors: Apply raceway products as specified below unless otherwise indicated.

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: IMC.
3. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Gymnasiums.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: GRC or IMC.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4X stainless steel in institutional and commercial kitchens and damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.

2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.


4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches of enclosures to which attached.

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L. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
5. Change from ENT to GRC or IMC before rising above floor.

M. Stub-ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. 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.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

S. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

T. Install raceway sealing fittings at accessible locations according to NFPA 70 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.
U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
   c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
   d. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per degree F of temperature change for PVC conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

W. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. 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. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.

Z. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
AA. Locate boxes so that cover or plate will not span different building finishes.

BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

DD. Set metal floor boxes level and flush with finished floor surface.

EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.

2. Install backfill as specified in Section 312000 "Earth Moving."

3. 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 of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."

4. Install manufactured duct elbows for stub-up at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.

   a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.

   b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.

6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDBOLES AND BOXES

A. 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.
B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

D. Install handholes with bottom below frost line, Insert depth of frost line below grade at Project site below grade.

E. 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.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION
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SECTION 260553
IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
4. Tapes and stencils.
5. Tags.
7. Cable ties.
9. Fasteners for labels and signs.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.

C. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS


B. Comply with NFPA 70.


D. Comply with ANSI Z535.4 for safety signs and labels.
E. Comply with NFPA 70E and Section 260573.19 "Arc-Flash Hazard Analysis" requirements for arc-flash warning labels.

F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
   1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:
   1. Black letters on an orange field.
   2. Legend: Indicate voltage and system or service type.

B. 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 240-V Circuits:
      a. Phase A: Black.
      b. Phase B: Red.
   4. Colors for 480/277-V Circuits:
      b. Phase B: Orange.
      c. Phase C: Yellow.
   5. Color for Neutral: White or gray.
   6. Color for Equipment Grounds: Green or Green with a yellow stripe.
   7. Colors for Isolated Grounds: Green two or more yellow stripes.

C. Warning Label Colors:
   1. Identify system voltage with black letters on an orange background.

D. Warning labels and signs shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

E. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Brady Corporation.
   b. Champion America.
   c. Panduit Corp.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameter and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Brady Corporation.
   b. Panduit Corp.


1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Brady Corporation.
   b. Ideal Industries, Inc.
   c. Panduit Corp.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.

3. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.

4. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. **Brady Corporation.**
   b. **Ideal Industries, Inc.**
   c. **Panduit Corp.**

2. **Minimum Nominal Size:**
   a. 1-1/2 by 6 inches for raceway and conductors.
   b. 3-1/2 by 5 inches for equipment.
   c. As required by authorities having jurisdiction.

### 2.4 BANDS AND TUBES

A. **Snap-around, Color-Coding Bands:** Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameter and that stay in place by gripping action.

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. **Brady Corporation.**
   b. **Panduit Corp.**

B. **Heat-Shrink Preprinted Tubes:** Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around item being identified. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. **Brady Corporation.**
   b. **Panduit Corp.**

### 2.5 TAPES AND STENCILS

A. **Marker Tapes:** Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. **Champion America.**
   b. **Ideal Industries, Inc.**
   c. **Panduit Corp.**

B. **Self-Adhesive Vinyl Tape:** Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. *Brady Corporation.*

C. **Tape and Stencil:** 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background and is 12 inches wide. Stop stripes at legends.

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. *LEM Products Inc.*
   b. *Seton Identification Products; a Brady Corporation company.*

D. **Floor Marking Tape:** 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with *yellow and black* stripes and clear vinyl overlay.

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. *Carlton Industries, L.P.*
   b. *Seton Identification Products; a Brady Corporation company.*

E. **Underground-Line Warning Tape:**

1. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. *Brady Corporation.*
   b. *Ideal Industries, Inc.*

2. **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 degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.

3. **Color and Printing:**

   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".

4. **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. Width: 3 inches.
c. Thickness: 4 mils.
d. Weight: 18.5 lb/1000 sq. ft.
e. Tensile according to ASTM D882: 30 lbf and 2500 psi.

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. Width: 3 inches.
c. Overall Thickness: 5 mils.
d. Foil Core Thickness: 0.35 mil.
e. Weight: 28 lb/1000 sq. ft..
f. Tensile according to ASTM D882: 70 lbf and 4600 psi.

F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 TAGS

A. Write-on Tags:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. LEM Products Inc.

2. Polyester Tags: 0.015 inch thick, with corrosion-resistant grommet and cable tie for attachment.
3. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
4. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 SIGNS

A. Baked-Enamel Signs:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Carlton Industries, L.P.
   b. Champion America.

2. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
3. 1/4-inch grommets in corners for mounting.

B. Metal-Backed Butyrate Signs:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Champion America.

2. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
3. 1/4-inch grommets in corners for mounting.
4. Nominal Size: 10 by 14 inches.

C. Laminated Acrylic or Melamine Plastic Signs:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Brady Corporation.
   b. Carlton Industries, L.P.

2. Engraved legend.
3. Thickness:
   a. For signs up to 20 sq. in., minimum 1/16 inch thick.
   b. For signs larger than 20 sq. in., 1/8 inch thick.
   c. Engraved legend with black letters on white face.
   d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
   e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.8 CABLE TIES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Ideal Industries, Inc.
2. Panduit Corp.

B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
3. Temperature Range: Minus 40 to plus 185 deg F.
C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

   2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
   3. Temperature Range: Minus 40 to plus 185 deg F.

D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

   2. Tensile Strength at 73 Deg F according to ASTM D638: 7000 psi.
   3. UL 94 Flame Rating: 94V-0.
   4. Temperature Range: Minus 50 to plus 284 deg F.
   5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

   A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

   B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

   A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

   B. Install identifying devices before installing acoustical ceilings and similar concealment.

   C. Verify identity of each item before installing identification products.

   D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

   E. Apply identification devices to surfaces that require finish after completing finish work.

   F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

   G. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.
H. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.

I. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
   1. Secure tight to surface of conductor, cable, or raceway.


K. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer and/or load shedding.

L. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

M. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
   1. "EMERGENCY POWER."
   2. "POWER."
   3. "UPS."

N. Vinyl Wraparound Labels:
   1. Secure tight to surface at a location with high visibility and accessibility.
   2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

O. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.

P. Self-Adhesive Wraparound Labels: Secure tight to surface of raceway or cable at a location with high visibility and accessibility.

Q. Self-Adhesive Labels:
   1. On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.

R. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

S. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
T. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

U. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
   
   1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

V. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.

W. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.

X. Underground Line Warning Tape:
   
   1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
   2. Limit use of underground-line warning tape to direct-buried cables.
   3. Install underground-line warning tape for direct-buried cables and cables in raceways.

Y. Write-on Tags:
   
   1. Place in a location with high visibility and accessibility.
   2. Secure using UV-stabilized cable ties.

Z. Baked-Enamel Signs:
   
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

AA. Metal-Backed Butyrate Signs:
   
   1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
   2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

BB. Laminated Acrylic or Melamine Plastic Signs:
   
   1. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.

CC. Cable Ties: General purpose, for attaching tags, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.2 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. 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 raceway labels.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

D. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

E. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use snap-around labels to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

F. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels with the conductor or cable designation, origin, and destination.

G. Control-Circuit Conductor Termination Identification: For identification at terminations, provide heat-shrink preprinted tubes with the conductor designation.

H. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source.

I. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

J. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.

K. Workspace Indication: Apply floor marking tape or tape and stencil to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.

L. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Baked-enamel warning signs.

   1. Apply to exterior of door, cover, or other access.
   2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:

      a. Power-transfer switches.
      b. Controls with external control power connections.


O. Operating Instruction Signs: Baked-enamel warning signs.

P. Emergency Operating Instruction Signs: Baked-enamel warning signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer and/or load shedding.

Q. Equipment Identification Labels:

   1. Indoor Equipment: Baked-enamel signs.
   2. Outdoor Equipment: Laminated acrylic or melamine sign.

END OF SECTION
SECTION 260923
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Time switches.
   2. Photoelectric switches.
   3. Standalone daylight-harvesting switching and dimming controls.
   4. Indoor occupancy and vacancy sensors.
   5. Switchbox-mounted occupancy and vacancy sensors
   7. High-bay occupancy and vacancy sensors.
   8. Outdoor motion sensors.
   9. Lighting contactors.

B. Related Requirements:
   1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:
   1. Show installation details for the following:
      a. Occupancy sensors.
      b. Vacancy sensors.
   2. Interconnection diagrams showing field-installed wiring.
   3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale and coordinated with each other, using input from installers of the items involved.

B. Field quality-control reports.

C. Sample warranty.
1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Software and firmware operational documentation.

1.5 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Industries, Inc.
2. Intermatic, Inc.
3. Leviton Manufacturing Co., Inc.
4. NSi Industries LLC.

B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST DPST DPDT.
3. Contact Rating: 30-A inductive or resistive, 277-V ac.
4. Programs: Eight on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
5. Programs: Two 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.
6. Programs: each channel is individually programmable with eight on-off set points on a 24-hour schedule.
7. Programs: each channel is individually programmable with two on-off set points on a 24-hour schedule with a skip-a-day weekly schedule.
8. Programs: each channel is individually programmable with two on-off set points on a 24-hour schedule, allowing different set points for each day of the week.
9. Programs: each channel is individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.
10. Programs: each channel is individually programmable with 40 on-off operations per week, plus four seasonal schedules that modify the basic program and an annual holiday schedule that overrides the weekly operation on holidays.
11. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
12. Astronomic Time: All channels.
14. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

C. Electromechanical-Dial Time Switches: Comply with UL 917.
   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Contact Configuration: SPST, DPST, SPDT, DPDT.
   3. Contact Rating: 30-A inductive or resistive, 277-V ac.
   4. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
   5. Astronomic time dial.
   7. Skip-a-day mode.
   8. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   1. Cooper Industries, Inc.
   2. Intermatic, Inc.
   3. Leviton Manufacturing Co., Inc.
   4. NSi Industries LLC.

B. Description: Solid state, with SPST, DPST dry contacts rated for 1000 W incandescent or 1800 VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.

   1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off.
   3. Time Delay: Fifteen-second minimum, to prevent false operation.
   5. Mounting: Twist lock complies with NEMA C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
   6. Failure Mode: Luminaire stays ON.

C. Description: Solid state; one set of NO dry contacts rated for 24 V ac at 1 A, to operate connected load, complying with UL 773, and compatible with luminaire, power pack, and/or lighting control panelboard.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
5. Failure Mode: Luminaire stays ON.
6. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
   a. LED status lights to indicate load status.
   b. Plenum rated.
7. Power Pack: Digital controller capable of accepting four RJ45 inputs with two outputs rated for 20-A incandescent or LED load at 120- and 277-V ac, for 16-A ballast or LED at 120- and 277-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
   a. With integral current monitoring.
   b. Compatible with digital addressable lighting interface.
   c. Plenum rated.

2.3 INDOOR OCCUPANCY AND VACANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cooper Industries, Inc.
2. Leviton Manufacturing Co., Inc.
3. Lithonia Lighting; Acuity Brands Lighting, Inc.
4. Lutron Electronics Co., Inc.
5. Schneider Electric USA (Square D).
6. Sensor Switch, Inc.

B. General Requirements for Sensors:

1. Wall and/or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
2. Dual technology.
3. Separate power pack.
4. Hardwired connection to switch and BAS; and BAS and lighting control system.
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:
   a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
b. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor
turns lights off when the room is unoccupied; with a time delay for turning lights off,
adjustable over a minimum range of 1 to 15 minutes.
c. Combination Sensor: Unless otherwise indicated, sensor shall be programmed to turn
lights on when coverage area is occupied and turn them off when unoccupied, or to turn
off lights that have been manually turned on; with a time delay for turning lights off,
adjustable over a minimum range of 1 to 15 minutes.

7. Sensor Output: Sensor is powered from the power pack.
9. Power Pack: Dry contacts rated for 20-A LED load at 120- and 277-V ac, for 13-A tungsten
at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as
defined by NFPA 70.
10. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

11. Indicator: Digital display, to show when motion is detected during testing and normal
operation of sensor.
12. Bypass Switch: Override the "on" function in case of sensor failure.
13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected
lighting level is present.

C. PIR Type: Ceiling mounted; detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a
human body that presents a target of not less than 36 sq. in..
2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area
of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
3. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 feet when
mounted on a 10-foot-high ceiling.
4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-
degree pattern centered on the sensor over an area of 2000 square feet when mounted 48
inches above finished floor.

D. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of
reflected ultrasonic energy.

1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12
inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600
sq. ft. when mounted on a 96-inch-high ceiling.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of
1000 sq. ft. when mounted on a 96-inch-high ceiling.
4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of
2000 sq. ft. when mounted on a 96-inch-high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on
a 10-foot-high ceiling in a corridor not wider than 14 feet.

E. Dual-Technology Type: Wall and/or Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.

2.4 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cooper Industries, Inc.
2. Legrand North America, LLC (WattStopper).
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. Schneider Electric USA (Square D).
7. Sensor Switch, Inc.

B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.

C. Wall-Switch Sensor Tag DT:

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft.
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
11. Faceplate: Color matched to switch.

D. Wall-Switch Sensor Tag IR:

1. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft..
2. Sensing Technology: PIR.
3. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off."
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
11. Faceplate: Color matched to switch.

2.5 DIGITAL TIMER LIGHT SWITCH

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cooper Industries, Inc.
2. Legrand North America, LLC (WattStopper).
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting; Acuity Brands Lighting, Inc.
5. Lutron Electronics Co., Inc.
6. Schneider Electric USA (Square D).
7. Sensor Switch, Inc.

B. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 10 minute increments.

1. Rated 960 W at 120-V ac for tungsten lighting, 10 A at 120-V ac or 10 amps at 277-V ac for ballast or LED, and 1/4 horsepower at 120-V ac.
2. Integral relay for connection to BAS.
3. Voltage: Match the circuit voltage.
5. Faceplate: Color matched to switch.

2.6 OUTDOOR MOTION SENSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Cooper Industries, Inc.
2. Legrand North America, LLC (WattStopper).
3. Leviton Manufacturing Co., Inc.
4. Lithonia Lighting: Acuity Brands Lighting, Inc.
5. Sensor Switch, Inc.

B. Description: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application, and shall comply with California Title 24.
2. Dual-technology (PIR and ultrasonic) type, weatherproof. Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. Comply with UL 773A.
3. Switch Rating:
   a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED.
   b. Separately Mounted Sensor: 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. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.

4. Switch Type: SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Match the circuit voltage type.
6. Detector Coverage:
   a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft.
   b. Long Range: 180-degree field of view and 110-foot detection range.

7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
10. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
11. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as "raftight" according to UL 773A.
2.7 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB (Electrification Products Division).
3. Eaton.
4. Schneider Electric USA (Square D).

B. Description: Electrically operated and mechanically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. 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 THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices matching the NEMA type specified for the enclosure.

2.8 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

C. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
D. 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.

E. 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.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch.

B. Wiring within Enclosures: Separate power-limited and nonpower-limited conductors in accordance with conductor manufacturer's written instructions.

C. Size conductors in accordance with lighting control device manufacturer's written instructions unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.3 IDENTIFICATION

A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Lighting control devices will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION
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SECTION 262416
PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Distribution panelboards.
   2. Lighting and appliance branch-circuit panelboards.

1.2 DEFINITIONS

A. MCCB: Molded-case circuit breaker.
B. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.
B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details.
   2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
   5. Include evidence of NRTL listing for series rating of installed devices.
   6. Include evidence of NRTL listing for SPD as installed in panelboard.
   7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   8. Include wiring diagrams for power, signal, and control wiring.
   9. Key interlock scheme drawing and sequence of operations.
   10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard schedules for installation in panelboards.
1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

   1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

B. 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.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

E. Enclosures: Flush and Surface-mounted, dead-front cabinets.

   1. Rated for environmental conditions at installed location.

      a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
      b. Outdoor Locations: NEMA 250, Type 3R.
      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.

   2. Height: 84 inches maximum.

   3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.

F. Incoming Mains Location: Bottom.

G. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.

H. Conductor Connectors: Suitable for use with conductor material and sizes.
   2. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
   3. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
   4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
   5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

I. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.

J. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.

L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

   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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.
2.3 POWER PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Eaton.
2. Schneider Electric USA (Square D).

B. Panelboards: NEMA PB 1, distribution type (“hybrid” lighting/power panels not allowed).

C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
   1. For doors more than 36 inches high, provide two latches, keyed alike.

D. Mains: Circuit breaker or Lugs only as indicated on drawings.


F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

G. Branch Overcurrent Protective Devices: Fused switches.

H. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. External Control-Power Source: 120-V branch circuit.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Eaton.
2. Schneider Electric USA (Square D).

B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

C. Mains: Circuit breaker or lugs only as indicated on drawings.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
   1. External Control-Power Source: 120-V branch circuit.

F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
G. Column-Type Panelboards: Single row of overcurrent devices with narrow gutter extension and overhead junction box equipped with ground and neutral terminal buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Eaton.
2. Schneider Electric USA (Square D).

B. MCCB: Comply with UL 489, with series-connected rating to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers:
   a. Inverse time-current element for low-level overloads.
   b. Instantaneous magnetic trip element for short circuits.
   c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.


3. Electronic Trip Circuit Breakers:
   a. RMS sensing.
   b. Field-replaceable rating plug or electronic trip.
   c. Digital display of settings, trip targets, and indicated metering displays.
   d. Multi-button keypad to access programmable functions and monitored data.
   e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
   f. Integral test jack for connection to portable test set or laptop computer.
   g. Field-Adjustable Settings:
      1) Instantaneous trip.
      2) Long- and short-time pickup levels.
      3) Long and short time adjustments.
      4) Ground-fault pickup level, time delay, and I squared T response.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
9. MCCB Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Breaker handle indicates tripped status.
c. UL listed for reverse connection without restrictive line or load ratings.
d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
g. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
h. Shunt Trip: 120-V or 24-V as required. Insert voltage trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."

2.6 IDENTIFICATION

A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.

B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.


2.7 ACCESSORY COMPONENTS AND FEATURES

A. 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.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NEC 1.

B. Install panelboards and accessories according to NEC 407.

C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
D. Mount top of trim 80 inches above finished floor unless otherwise indicated.

E. Mount panelboard cabinet plumb and rigid without distortion of box.

F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.
   1. Set field-adjustable, circuit-breaker trip ranges.

H. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

I. Install filler plates in unused spaces.

J. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.

K. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION
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SECTION 262726
WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Standard-grade receptacles, 125 V, 20 A.
   2. USB receptacles.
   3. GFCI receptacles, 125 V, 20 A.
   4. Toggle switches, 120/277 V, 20 A.
   5. Decorator-style devices, 20 A.
   6. Occupancy sensors.
   7. Digital timer light switches.
  10. Wall plates.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Comply with NFPA 70.

C. RoHS compliant.
D. Comply with NEMA WD 1.

E. Device Color:

2. Wiring Devices Connected to Essential Electrical System: Red.
3. SPD Devices: Blue.
4. Isolated-Ground Receptacles: Orange.

F. Wall Plate Color: Stainless steel, satin finish.

G. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 COMMERCIAL-GRADE RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.

B. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Weather-Resistant Duplex Receptacle, 125 V, 20 A:

SP 22-7 TULSA POLICE DEPARTMENT HELIPORT
BKL Project No. 811
MARCH 27, 2023
202726 - 2
1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. **Description:** Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. **Configuration:** NEMA WD 6, Configuration 5-20R.
4. **Standards:** Comply with UL 498.
5. **Marking:** Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.

**D. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 20 A:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. **Description:** Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. **Configuration:** NEMA WD 6, Configuration 5-20R.
4. **Standards:** Comply with UL 498.
5. **Marking:** Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

**2.3 USB RECEPTACLES**

**A. USB Charging Receptacles:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. **Description:** Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
3. **USB Receptacles:** Dual and quad, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. **Standards:** Comply with UL 1310 and USB 3.0 devices.
B. Tamper-Resistant Duplex and USB Charging Receptacles:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap. Integral shutters that operate only when a plug is inserted in the line voltage receptacle.

3. Line Voltage Receptacles: Two pole, three wire, and self-grounding; NEMA WD 6, Configuration 5-20R.

4. USB Receptacles: Dual USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).

5. Standards: Comply with UL 498, UL 1310, USB 3.0 devices, and FS W-C-596.


### 2.4 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.

3. Configuration: NEMA WD 6, Configuration 5-20R.

4. Type: Feed through.

5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. Hubbell Incorporated (Wiring Device-Kellems).
   b. Legrand North America, LLC (Pass & Seymour).

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellem's).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-15R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498 and UL 943 Class A.
6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.5 TOGGLE SWITCHES, 120/277 V, 20 A

A. Single-Pole Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellem's).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Standards: Comply with UL 20 and FS W-S-896.

B. Two-Pole Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellem's).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.
2. Comply with UL 20 and FS W-S-896.

C. Three-Way Switches, 120/277 V, 20 A:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Comply with UL 20 and FS W-S-896.

D. Four-Way Switches, 120/277 V, 20 A:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Standards: Comply with UL 20 and FS W-S-896.

E. Lighted Single-Pole Switches, 120/277 V, 20 A:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Hubbell Premise Wiring).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Handle illuminated when switch is off.
3. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

**2.6 DECORATOR-STYLE DEVICES, 20 A**

A. Decorator Duplex Receptacles, 125 V, 20 A:

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
d. Leviton Manufacturing Co., Inc.

2. Description: Two pole, three wire, and self-grounding. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.

B. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Decorator Single-Pole Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.
2. Comply with UL 20.

E. Decorator Single-Pole Lighted Switches, 120/277 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Square face illuminated when circuit is switched off.

2.7 OCCUPANCY SENSORS

A. Wall Switch Sensor Light Switch, Dual Technology:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.

2. Description: Switchbox-mounted, combination lighting-control sensor and conventional switch lighting-control unit using dual (ultrasonic and passive infrared) technology.
4. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
5. Adjustable time delay of 10 minutes.
6. Able to be locked to Automatic-On mode.
8. Connections: Provisions for connection to BAS.

B. Wall Sensor Light Switch, Passive Infrared:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Cooper Industries.
   b. Hubbell Incorporated (Hubbell Premise Wiring).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.
2. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using passive infrared technology.
4. Connections: Provisions for connection to BAS.
7. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
8. Integral relay for connection to BAS.
9. Adjustable time delay of 10 minutes.
10. Able to be locked to Automatic-On mode.

C. Wall Sensor Light Switch, Ultrasonic:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Leviton Manufacturing Co., Inc.

2. Description: Switchbox-mounted, combination, lighting-control sensor and conventional switch lighting-control unit using ultrasonic technology.
4. Connections: Provisions for connection to BAS.
7. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
8. Integral relay for connection to BAS.
9. Adjustable time delay of 10 minutes.
10. Able to be locked to Automatic-On mode.

2.8 TIMER LIGHT SWITCH

A. Digital Timer Light Switch:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Leviton Manufacturing Co., Inc.

2. Description: Switchbox-mounted, combination digital timer and conventional switch lighting-control unit, with backlit digital display, with selectable time interval in 10-minute increments.
4. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
5. Integral relay for connection to BAS.

2.9 DIMMERS

A. Wall-Box Dimmers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

   a. Eaton (Wiring Devices - Arrow Hart).
   b. Hubbell Incorporated (Wiring Device-Kellems).
   c. Legrand North America, LLC (Pass & Seymour).
   d. Leviton Manufacturing Co., Inc.
   e. Lutron Electronics Co., Inc.

2. Description: Modular, full-wave, solid-state dimmer switch with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

3. Control: Continuously adjustable slider; with single-pole or three-way switching.


5. 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.

6. 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.

7. LED Lamp Dimmer Switches: Modular; compatible with LED lamps; trim potentiometer to adjust low-end dimming; capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.10 WALL PLATES

A. Single Source: Obtain wall plates from same manufacturer of wiring devices.

B. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch-thick, satin-finished, Type 302 stainless steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.
PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NEC A 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:
   1. 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.
   2. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is trawled flush with the face of the wall.
   3. Install wiring devices after all wall preparation, including painting, is complete.

C. Device Installation:
   1. Connect devices to branch circuits using pigtales that are not less than 6 inches in length.
   2. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

D. Receptacle Orientation:
   1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.
   2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

E. 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.

F. Dimmers:
   1. Install dimmers within terms of their listing.
   2. Verify that dimmers used for fan-speed control are listed for that application.
   3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

G. 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.

H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
1. In healthcare facilities, prepare reports that comply with NFPA 99.
2. Test Instruments: Use instruments that comply with UL 1436.
3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

B. Tests for Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION
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SECTION 263213.16
GAS-ENGINE DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes:

1. Engine.
2. Gas fuel system.
3. Alternator.
4. Unit-mounted radiator.
5. Control and monitoring.
6. Generator overcurrent and fault protection.
7. Generator, exciter, and voltage regulator.

B. Related Requirements:

1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and stopping signals for engine generators.

1.3 DEFINITIONS

A. AREP: Auxiliary winding regulation excitation principle. Voltage support for the AVR comes from independent auxiliary windings located in the main stator.

B. AVR: Automatic voltage regulator.

C. EPS: Emergency power supply.

D. EPSS: Emergency power supply system.

E. LP: Liquid petroleum.

F. NG: Natural Gas

G. 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.
H. PMG: Permanent magnet generator. Voltage support for the AVR comes from an independent auxiliary permanent magnet generator which is mounted on the shaft extension of the alternator.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.
3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in cubic feet per hour at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, and reference air supply temperature. Provide drawings indicating requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer .

B. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
4. Report of factory test on units to be shipped for this Project, indicating evidence of compliance with specified requirements.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For engine generators to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

   a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
   b. Operating instructions mounted adjacent to generator location.
   c. Training plan.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
3. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

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PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Rolls-Royce Solutions America Inc.; GS Series or a comparable product by one of the following:

2. Cummins Power Generation.
4. 

B. Source Limitations:

1. Obtain packaged engine generators and auxiliary components from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to 2018.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: 1.5.


C. CSA Compliance:

2. Comply with CSA 282.

D. NFPA Compliance:

2. Comply with NFPA 70.
4. Comply with NFPA 110 requirements for Level 1 EPSS.

E. UL Compliance: Comply with UL 2200.

F. Engine Exhaust Emissions: Comply with EPA Tier 2 requirements and applicable state and local government requirements.

G. Noise Emission: Comply with applicable state and local government requirements 72dB for maximum noise level at 7 ft due to sound emitted by engine generator, including engine, engine
exhaust, engine cooling-air intake and discharge, and other components of installation. Comply with ISO 8528-10 for sound measurements at 3.2 feet and 23.0 feet.

H. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: minus 4 to plus 122 deg F.
2. Relative Humidity: Zero to 100 percent.
3. Altitude: Sea level to 728ft.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

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

C. Power Rating: Standby.

D. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

E. EPSS Class: Engine generator shall be classified as according to NFPA 110.

F. Service Load: 250 kVA.

G. Power Factor: 0.8, lagging or leading.

H. Frequency: 60 Hz.

I. Voltage: 240-V ac.

J. Phase: Three phase, four -wire, wye.

K. Induction Method: Best fit.

L. Governor: Adjustable isochronous, with speed sensing.

M. Mounting Frame: Structural-steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. 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.

N. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries, with capacity required to operate as a unit as evidenced by records of prototype testing.

2. Nameplates: For each major system component to identify manufacturer’s name, model, and serial number, of component.

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O. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 0.25 percent of rated output voltage, from no load to full load, and one-percent for non-PMG alternators.
2. Load Factor: 85-percent load factor according to ISO 8528-1.
   a. If rated load factor is below, supplier must provide updated documents for performance modified to 85-percent load factor in regards to time before overhaul (TBO) and the respective maintenance schedule.
3. Transient Voltage Performance: Not more than 30 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 3-seconds.
4. Steady-State Frequency Operational Bandwidth: One-percent of rated frequency, from no load to full load.
5. 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.
6. Transient Frequency Performance: Less than 10 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
7. 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.
8. Sustained Short-Circuit Current: For a three-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 with PMG/AREP, without damage to generator system components.
9. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 GAS ENGINE

A. Fuel: NG.

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid mounted.
   1. Filter and Strainer: Select according to engine manufacturer's requirements for particle removal.
   2. 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.
   3. 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.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity and with UL 499.
E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Glycol-based antifreeze and water mixture for freeze protection to minus 30 deg F, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant, from cold start to 100 percent load condition.
3. Expansion Tank: Rated to withstand maximum closed-loop coolant-system pressure for engine used. Equip with gage glass and petcock. Replace gage glass with a pressure sensor when gage glass is located more than 8 feet from the floor.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
   a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
   b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Air-Intake Filter: Single-stage, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

G. Starting System: 24-V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle, with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: required by NFPA 110 for system level specified.
4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide NFPA 110 specified cranking cycle without recharging.
5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Include accessories required to support and fasten batteries in place.
   a. Compartment Heater: Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article.
   b. Compartment Ventilation: Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
a. 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.

b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.

1) Temperature Probe: Equip battery charger with a temperature probe on the negative cable when battery heaters are used.

c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.


e. 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.

f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 GAS FUEL SYSTEM

A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:

1. NG Withdrawal System.

   a. Carburetor.
   b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
   d. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.6 CONTROL AND MONITORING

A. 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 engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Provide minimum run-time control set for 30 minutes, with override only by operation of a remote emergency-stop switch.
C. Comply with UL 2200 for stationary engine generator assemblies and UL 508A for ancillary controls, such as Master Control Panel mounted off the generator set.

D. Configuration:

1. Operating and safety indications, protective devices, basic system controls, and engine gauges will be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method will isolate the control panel from generator-set vibration. Panel will be powered from the engine generator battery.

2. Operating and safety indications, protective devices, basic system controls, engine gauges, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components will be grouped in a combination control and power panel. Control and monitoring section of panel will be isolated from power sections by steel barriers. Panel will be powered from the engine generator battery. Panel features to include the following:

   b. Switchboard Construction: Freestanding unit complying with Section 262413 "Switchboards." Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
   c. Switchgear Construction: Freestanding unit complying with Section 262300 "Low-Voltage Switchgear."


4. Controller Compliance: Comply with UL, NFPA, CSA, and CE.

5. Software: <Insert controller software requirements>.

6. Parallel Controllers:

E. Control and Monitoring Panel:

1. Digital controller with integrated LCD display, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.

   a. PLC logic incorporating drag and drop ladder logic available for the owner/user. Logic shall be designed such that all parameters within the generator set controller can be used in addition to additional inputs and outputs.

2. Instruments: Located on the control and monitoring panel and viewable during operation.

   a. Engine lubricating-oil pressure gage.
   b. Engine-coolant temperature gage.
   c. DC voltmeter (alternator battery charging).
   d. Running-time meter.
   e. AC voltmeter, connected to a phase selector switch.
   f. AC ammeter, connected to a phase selector switch.
   g. AC frequency meter.
   h. Digital generator-voltage-adjusting feature to allow plus or minus 5 percent adjustment.

3. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm and pre-alarm indication, including the following:
a. Cranking control equipment.
c. Control switch not in automatic position alarm.
d. Overcrank alarm.
e. Overcrank shutdown device.
f. Low water temperature alarm.
g. High engine temperature prealarm.
h. High engine temperature.
i. High engine temperature shutdown device.
j. Engine exhaust temperature.
k. High engine exhaust temperature alarm.
l. Overspeed alarm.
m. Overspeed shutdown device.
n. Low fuel main tank.

1) Low-fuel-level alarm to be initiated when the level falls below that required for operation for the duration required for the indicated EPSS class.

o. Coolant low-level alarm.
p. Coolant low-level shutdown device.
qu. Coolant high-temperature prealarm.
r. Coolant high-temperature alarm.
s. Coolant low-temperature alarm.
t. Coolant high-temperature shutdown device.
u. EPS supplying load indicator.
v. Battery high-voltage alarm.
w. Low cranking voltage alarm.
x. Battery-charger malfunction alarm.
y. Battery low-voltage alarm.
z. Lamp test.

aa. Contacts for local and remote common alarm.
bb. Low-starting air pressure alarm.
cc. Low-starting hydraulic pressure alarm.
dd. Remote manual stop shutdown device.

ee. Hours of operation.
ff. Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.
gg. Generator overcurrent protective device not closed alarm.
hh. Generator overspeed.
i. Generator over and under voltage.
jj. Dead bus.
kk. Reverse power.
ll. Ground fault control.

5. Cranking control equipment.

F. Engine Generator Metering: Comply with .

G. Connection to Datalink:
1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
2. Provide connections for datalink transmission of indications to remote data terminals via ModBus. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."
3. Provide USB communication interface.
4. Additional inputs and outputs:
   a. Inputs:
      1) Digital: 26 configurable digital inputs.
      2) Thermocouples: Two.
      3) RTD: 8 RTD inputs.
   b. Outputs:
      1) 30-A: 3 configurable outputs.
      2) 10-A: 10 configurable outputs.
      3) 4-A: 12 configurable outputs.
      4) 2-A: 12 configurable outputs.
      5) 1-A: 12 configurable outputs.
      6) Analog: 4 configurable analog inputs.

H. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

I. Remote Display Panel: Comply with NFPA 99. An LED indicator light 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.

1. Overcrank alarm.
2. Coolant low-temperature alarm.
3. High engine temperature prealarm.
4. High engine temperature alarm.
5. Low lube oil pressure alarm.
6. Overspeed alarm.
7. Low-fuel main tank alarm.
8. Low coolant level alarm.
9. Low-cranking voltage alarm.
10. Contacts for local and remote common alarm.
13. Control switch not in automatic position alarm.
15. Fuel tank high-level shutdown of fuel supply alarm.
16. Lamp test.
17. Low-cranking voltage alarm.
18. Generator overcurrent-protective-device not-closed alarm.

J. Remote Emergency-Stop Switch: Flush; wall mounted unless otherwise indicated; and labeled. Push button will be protected from accidental operation.

K. 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.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs.

1. Overcurrent protective devices for the entire EPSS will be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices will consider both utility and EPSS as the voltage source.

2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:

1. Molded-case circuit breaker, thermal-magnetic type; 100 percent rated; complying with UL 489:
   a. Tripping Characteristic: Designed specifically for generator protection.
   b. Trip Rating: Matched to generator output rating.
   c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
   d. Mounting: Adjacent to, or integrated with, control and monitoring panel.

C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground fault.

1. Indicate ground fault with other engine generator alarm indications.

2. Trip generator protective device on ground fault.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12-lead alternator.

E. Range: Provide limited range of output voltage by adjusting the excitation level.
F. Construction prevents mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 100 percent of rated capacity.

G. Enclosure: Dripproof.
   1. Ingress Protection Rating (IP): Follow IEC 60529 and IP23.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified and required by NFPA 110.
   1. Digital Adjustment on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
   2. Maintain voltage within 30 percent on one step, full load.
   3. Provide anti-hunt provision to stabilize voltage.
   4. Maintain frequency within 15 percent and stabilize at rated frequency within 2 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Best fit pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 11 to 30 percent, maximum.

2.9 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description:
   1. Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 130 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Instruments and control shall be mounted within enclosure.

B. Structural Design and Anchorage: Comply with ASCE/SEI 7-10 for wind loads up to 130 mph.

C. Fire Protection: Provide fire protection in accordance with Provide smoke detector in enclosure; mounted according to NFPA 72.

D. Hinged Doors: Manufacturer's standard construction with padlocking provisions.

E. Space Heater: Thermostatically controlled and sized to prevent condensation.

F. Lighting: Provide weather-resistant AC/DC-powered LED lighting with 50 fc average maintained.

G. 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 components.

H. Muffler Location: Within enclosure.
I. Engine-Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 100 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof, drainable, gravity, louvers to prevent entry of rain and snow.
2. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

J. Interior Lights with Switch: Factory-wired, vapor-proof fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.
2. DC lighting system for operation when remote source and generator are both unavailable.


L. Sound Attenuation: When measured at 3.2 feet and 23.0 feet from sides of unit, attenuation shall be 72 dBA or less. Octave band sound report shall be provided based on similar unit construction.

2.10 VIBRATION ISOLATION DEVICES

A. 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.


B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. 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-thick, elastomeric isolator pad incorporated into isolator housing; and adjustable equipment-mounting and leveling bolt that acts as blocking during installation.

C. Comply with requirements in Section 232116 "Hydronic Piping Specialties" for vibration isolation and flexible connector materials for steel piping.

D. Comply with requirements in Section 233113 "Metal Ducts" for vibration isolation and flexible connector materials for exhaust shroud and ductwork.

E. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 FINISHES

A. Indoor Enclosures and Components: Powder-coated finish over steel enclosure.


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B. Outdoor Enclosures and Components: Powder-coated finish over steel enclosure.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
   1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
   2. Test generator, exciter, and voltage regulator as a unit.
   3. Full-load run.
   4. Maximum power.
   5. Voltage regulation.
   6. Transient and steady-state governing.
   8. Safety shutdown.
   9. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
   10. Report factory test results within 5 days of completion of test.
      a. Report factory test results within 48 hours of completion of a customer witness test at the factory.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.
3.2 PREPARATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to 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:

1. Notify Construction Manager Owner no fewer than two working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's Owner's written permission.

3.3 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete.
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with elastomeric isolator pads & restrained spring isolators having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Drain Piping: Install condensate drain piping to muffler drain outlet with a shutoff valve, stainless-steel flexible connector, and Schedule 40 black steel pipe, the full size of the drain connection, with welded joints.

F. Gaseous Fuel Piping:

1. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
2. LP gas piping, valves, and specialties for gas piping are specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping."

G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

C. Connect cooling-system water piping to engine generator and heat exchanger with flexible connectors.

D. Connect engine exhaust pipe to engine with flexible connector.

E. Gaseous Fuel Connections:
   1. Connect fuel piping to engines with a gate valve and union and flexible connector.
   2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
   3. Vent gas pressure regulators outside building a minimum of 60 inches from building openings.

F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

H. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency:
   1. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:
   1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs below, as specified in the NETA ATS. Certify compliance with test parameters.
      a. Visual and Mechanical Inspection:
1) Compare equipment nameplate data with drawings and specifications.
2) Inspect physical and mechanical condition.
3) Inspect anchorage, alignment, and grounding.
4) Verify the unit is clean.

b. Electrical and Mechanical Tests:

1) Perform insulation-resistance tests in accordance with IEEE 43.
   
   a) Machines larger than 200 hp. Test duration shall be 10 minutes. Calculate polarization index.
   b) Machines 200 hp or less: Test duration shall be one minute. Calculate the dielectric-absorption ratio.
   c) Test is allowed to be done by the manufacturer during assembly in the case where field test requires disassembly of factory wiring and can void warranty.

2) Test protective relay devices.
3) Verify phase rotation, phasing, and synchronized operation required by the application.
4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
5) Perform vibration test for each main bearing cap.
6) Verify correct functioning of the governor and regulator.

2. 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.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

   a. 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.
   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
   c. Verify acceptance of charge for each element of the battery after discharge.
   d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. 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.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. 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.

7. Exhaust Emissions Test: Comply with applicable government test criteria.

8. 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.

9. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
10. 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 25 feet from edge of the generator enclosure, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest as specified above.

I. Retest: Correct deficiencies identified by tests and observations, and retest until specified requirements are met.

J. 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.

K. Infrared Scanning: After Substantial Completion, but not more than 60 days after final acceptance, perform an infrared scan of each power wiring termination and each bus connection while running with maximum load. Remove all access panels, so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 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 terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.7 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months’ full maintenance by skilled employees of manufacturer’s designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.
3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

3.9 LONG TERM STORAGE

A. In the event the packaged engine generator sits for more than one month without being operated, the following provisions shall be followed:

1. Comply with the manufacturer's storage requirements.
2. Provide fuel conditioning and stabilizing for onsite fuel.
3. Engage a factory-authorized service technician to put packaged engine generator back into service before running.

END OF SECTION 263213.16
SECTION 263600
TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Transfer switch controller.
2. Closed transition, contactor type, bypass isolation transfer switches.
3. Transfer switch accessories.

1.2 DEFINITIONS

A. Automatic Transfer Switch (ATS): Device in which a controller manages the entire process, and initiation begins when the controller senses a loss of the primary source. The controller monitors the source voltage and sends a command to the generators to run when the voltage falls below a preset limit for a prescribed period. The controller also monitors the secondary source voltage and frequency, and when these values are within acceptable limits, the switch transfers the load from the primary to the secondary source. When the primary source is reestablished for a prescribed period to ensure stability, the switch may automatically transfer the load back to the primary source. Most critical and life-safety loads require automatic operation as defined by the NEC.

B. Bypass Isolation Transfer Switch: Transfer switch that incorporates a standard automatic and a manual transfer switch into a single unit. Bypass isolation is used to transfer power to the manual switch to allow servicing of the ATS while maintaining power to connected loads.

1. Mechanically Operated: Physical handle is used to select between manual and automatic sides of the bypass isolation transfer switch.
2. Electrically Operated: Push-button controls are used to select between manual and automatic sides of the bypass isolation transfer switch.

C. Contactor type switching mechanism: Contactors are constructed as an electrically controlled, double-throw switch where a solenoid mechanism opens one set of power contacts while closing a second set.

D. Enclosures: The following are UL 50 definitions of enclosure types listed in order of protection from least hazardous to most severe conditions.

1. Type 1: Enclosures constructed for indoor use to provide a degree of protection to personnel against incidental contact with the enclosed equipment and to provide a degree of protection against falling dirt.
2. Type 3R: Constructed (with knockouts on the sides and bottom) for either indoor or outdoor use to provide protection against falling dirt, rain, sleet, snow, and windblown dust. Will be undamaged by the external formation of ice on the enclosure. Type 3R enclosures are rainproof,
which means they are constructed, protected, or treated to prevent beating rain from interfering with the successful operation of the apparatus or result in wetting of live parts and wiring within the enclosure under specified conditions. They are not raintight, which means exposure to beating rain could result in water entering a Type 3R enclosure under certain conditions; nor are they watertight, which means moisture could enter a Type 3R enclosure when subjected to a stream of water under certain conditions.

3. Type 4: Constructed for either indoor or outdoor use to provide protection against falling dirt, rain, sleet, snow, windblown dust, splashing water, and hose-directed water. Will be undamaged by the external formation of ice on the enclosure.

4. Type 4X: Same as Type 4 except constructed from corrosion-resistant material. As defined by industry standards, corrosion resistant means constructed to provide a degree of protection against exposure to corrosive agents such as salt spray. Stainless steel is the strongest of the corrosion-resistant materials. It exhibits many of the same resistances attributed to fiberglass materials as well as resistance to highly polar solvents such as acetone and MEK. Type 316 grade stainless steel is an option that provides improved resistance to salt, some acids, and high temperature. Type 316 grade is a strongly recommended choice for marine environments that are within five miles of salt water or otherwise subject to exposure to salt spray. Note that Type 316 grade resistance to sulfates and chlorine is less than that provided by Type 304 grade.

5. Type 12: Constructed (without knockouts) for indoor use to provide protection against falling dirt; against circulating dust, lint, fibers, and flying debris; against dripping and light splashing of noncorrosive liquids; and against light splashing and consequent seepage of oil and noncorrosive coolants. Type 12 enclosures are oil resistant, and constructed so oil will not interfere with successful operation of equipment. They are not oiltight, which means oil could enter a Type 12 enclosure under certain conditions.

E. Insulated-Case Type Switching Mechanism: Provides electronic trip overcurrent protection using UL 1558 listed circuit breakers (100 percent rated).

F. Manual Transfer Switch: Transfer switch in which the entire process is completed manually by an operator. There is not typically a controller, voltage-sensing equipment, or electrical mechanism used to operate the load transfer. Manual switches are the most basic types of transfer switch and are common in noncritical facilities or applications.

G. Molded-Case Type Switching Mechanism: Provides thermal-magnetic or electronic trip overcurrent protection using UL 489 listed circuit breakers (80 percent rated).

H. Non-Automatic Transfer Switch: Transfer switch that is manually initiated by an operator and then an internal device within the switch equipment operates the transfer switch by electric operation. The operator has the ability to determine when to initiate the load transfer, but the actual transfer operation is electrically actuated.

I. Service Entrance Transfer Switch: Transfer switch that serves as both ATS and utility service disconnect.

J. Transition Types:

1. Standard (Open) Transition: Break-before-make transfer. In open transition, the load is disconnected from one normal source before being connected to the alternate emergency source.
2. Programmed (Delayed) Transition: Break both normal and emergency sides before transfer. The load disconnects from one source, and then pauses in an “off” position before connecting to the alternate source to protect from power surges. The delay allows the magnetic field to decay to a safe level before transferring.

3. Closed Transition: Make-before-break transfer. The source from which the load is being transferred remains closed until the source to which the load will be transferred is also closed. After both sources are closed, the source from which power is being transferred is opened.

K. Withstand and Close-On Rating (WCR): The following are the types of transfer switch WCR ratings.

1. Specific Breaker Rating: Transfer switch that is tested in coordination with specific upstream circuit breakers. Only breakers listed on the transfer switch rating decal may be used.

2. Time-Based Rating (Any Breaker): Transfer switch that passes the "any breaker" test can withstand a fault of a given magnitude for three cycles. This allows an ATS to be used with any UL 489 circuit breaker.

3. Short-Time Rating: The short-time ratings require longer-duration application of fault current and are intended for selective coordination purposes, where an extended delay is needed to allow for downstream protective devices to clear a fault closer to its source.

4. Fuse Disconnect: A device used for limiting the amount of fault current that passes through a system and protects downstream power system components from catastrophic failure. When fault current exceeds the current rating, the circuit is opened, and a new fuse is required to make the system operational again. These devices are typically used when fault current exceeds ratings for other options.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.

2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.

2. Include material lists for each switch specified.

3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and/or bypass/isolation switch.

4. Riser Diagram: Show interconnection wiring between transfer switches, annunciators, and control panels.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Field quality-control reports.
1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
   a. Features and operating sequences, both automatic and manual.
   b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. ISO 9001 certified for design, development, production, and service of complete product line.
2. Produced this type of equipment for a period of at least 10 years.
3. Actively maintaining a 24-hour parts and service organization regularly engaged in maintenance contract programs to perform preventive maintenance and service on equipment like that specified.
4. Furnish a service agreement that includes system operation under simulated operating conditions; adjustment to the generator set, transfer switch, and switchgear controls, and certification in the Owner's maintenance log of repairs made and functional tests performed on all systems.
5. Transfer switch, engine-driven generator assembly, and paralleling switchgear (if applicable) must be furnished by a single manufacturer, responsible for design, coordination, and testing of the complete system.

B. Testing Agency Qualifications:

1. Member company of NETA.
   a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 1 years from date of registered startup or commissioning.
2. Transfer switch and accessories to include a standard one-year warranty against defective material and workmanship in accordance with manufacturer's published warranty from registered startup date.
3. Extended Warranty: Limited five-year warranty including repair parts and labor in accordance with manufacturer's published warranty.
PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Basis-of-Design Product: Subject to compliance with requirements, provide MTU Solutions; transfer switches or comparable product by one of the following:

3. Cummins Inc.

B. Source Limitations: Manufacturer must supply generators, transfer switches, and paralleling switchgear for single-source warranty, parts, and service through a factory authorized representative with factory-trained technicians.

C. 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.

D. Comply with NEMA ICS 1.

E. Comply with NFPA 110.

F. Comply with UL 1008 unless requirements of these Specifications are stricter.

G. Retain first paragraph below as an optional feature.


I. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 800 A and higher, to have separate arcing contacts.
3. Inspection of all contacts possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 800 A and higher must have front removable and replaceable contacts. All stationary and moveable contacts replaceable without removing power conductors or bus bars.
4. Main and Neutral Lugs: Mechanical type.
6. Conductor Connectors: Suitable for use with conductor material and sizes.
7. Ground Lugs and Bus-Configured Terminators: Mechanical type.
8. Connectors to be marked for conductor size and type in accordance with UL 1008.

J. 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.
K. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing in accordance with UL 1008.

L. Repetitive Accuracy of Solid-State Controls: All settings to be plus or minus 0.5 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

M. Resistance to Damage by Voltage Transients: Components meet or exceed voltage-surge withstand capability requirements when tested in accordance with IEEE C62.62. Components meet or exceed voltage-impulse withstand test of NEMA ICS 1.

N. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes to be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition or manual transfer.

O. Neutral: Ampacity and switch rating of neutral path through units to be the nominal rating of circuit in which switch is installed.

P. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color code or by numbered or lettered wire and cable markers at terminations.

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

2.2 TRANSFER SWITCH CONTROLLER

A. Requires automatic transfer switch controller.

B. Display: Integral to controller for viewing all available data and setting desired operational parameters. Operational parameters also available for viewing and control through communications interface port or USB. The following parameters are only adjustable via password-protected programming on the controller:

a. Nominal line voltage and frequency.
b. Single- or three-phase sensing.
c. Operating parameter protection.

C. Controller capable of sensing phase rotation of both normal and emergency sources. Source is considered unacceptable if phase rotation is not the preferred rotation selected (ABC or BAC). Unacceptable phase rotation indicated on LCD; service required LED and annunciation through the communication protocol and dry contacts. Phase rotation sensing capable of being disabled, if required.

D. Controller capable of detecting a single phasing condition of a source, even though a voltage may be regenerated by the load. This condition is a loss of phase and considered a failed source.
E. Source status screens provided for both normal and emergency sources to provide digital readout of voltage on all three phases (phase to phase and phase to neutral), frequency, and phase rotation.

F. Test Switch: Simulate normal-source failure.

G. Switch-Position Indicating Lights: Indicate source to which load is connected.

   1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

I. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240 V(ac).

J. Transfer Override Switch: Overrides automatic retransfer control so that transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.

K. Controller operates through a period of loss of control power.

L. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage to be adjustable from 85 to 100 percent of nominal, and dropout voltage to be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 90 percent.

M. Overvoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage to be adjustable from 95 to 100 percent of dropout, and dropout voltage to be adjustable from 106 to 135 percent of nominal value. Factory set for pickup at 95 percent and dropout at 110 (600V) or 115 percent.

N. Voltage Unbalance Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage to be adjustable from 3 to 18 percent of nominal, and dropout voltage to be adjustable from 5 to 20 percent of nominal value. Factory set for pickup at 10 percent and dropout at 20 percent.

O. Under-frequency: Prevent premature transfer to generator. Pickup frequency to be adjustable from 80 to 95 percent of nominal. Factory set for pickup at 90 percent. Dropout frequency to be adjustable from 95 to 99 percent of nominal. Factory set for pickup at 99 percent of dropout.

P. Over-frequency: Prevent premature transfer to generator. Pickup frequency to be adjustable from 105 to 120 percent of nominal. Factory set for pickup at 110 percent. Dropout frequency to be adjustable from 101 to 115 percent of nominal. Factory set for dropout at 101 percent.

Q. Time Delays:
   1. Momentary Genset Start Delay: Adjustable time delay of zero to 15 seconds to override momentary normal source outages and delay all transfer and engine starting signals. Capable of extended time delay up to 60 minutes by providing an external 12 or 24 V(dc) power supply.
2. Transfer to Emergency Source: Adjustable from zero to 60 minutes provided on transfer to the emergency source for controlled timing of transfer of loads to emergency. Factory setting is three seconds.
3. Retransfer to Normal Source: Adjustable from zero to 60 minutes time delay for re-transfer to normal. Time delay automatically bypassed if the emergency source fails and the normal source is acceptable. Factory setting is 15 minutes.
4. Engine Cool Down: Adjustable from zero to 60 minutes provided on shutdown of engine generator for cool down. Factory setting is five seconds.

R. Time Delay Outputs: Time delay activated output signals to drive external relay(s) for selective load disconnect and reconnect control. Capable of controlling nine individual output time delays to step loads on after a transfer occurs. Each output individually programmed for independent time delay from zero to 60 minutes. Each sequence independently programmed for transferring from normal to emergency and transferring from emergency to normal.

S. Engine Shutdown Contacts:
   1. Time Delay: Adjustable from zero to five minutes, and factory set for five minutes. Contact initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

T. Signal-Before-Transfer Contacts: One set of normally open/normally closed dry contacts that operate in advance of retransfer to normal source. Interval adjustable from one to 30 seconds.

U. 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. Up to 21 different exercise events can be set with different settings of various parameters. Maximum exercise run time is 24 hours. Exerciser features include the following:
   1. Push-button programming control with digital display of settings.

V. Integral battery operation of time switch when normal control power is unavailable.

W. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel Modbus 485.

X. Ethernet Board: RJ-45 connection for communication capability with Modbus TCP/IP protocol.

Y. Controller Logic Disconnect Switch: Two-position switch, mounted inside the enclosure to disconnect three-phase voltage sensing and power to controller without disconnecting the load for use during maintenance and service. The switch has two positions, auto and disconnect. User must manually disable generator prior to placing the controller logic disconnect in OFF position.

2.3 CLOSED TRANSITION, CONTACTER TYPE, BYPASS ISOLATION TRANSFER SWITCH

A. Provide as indicated in drawings.

B. Automatic Closed-Transition Transfer Switches: Connect both sources to load momentarily. Transition is controlled by programming in the automatic transfer-switch controller.
1. Fully automatic make-before-break operation when transferring between two available power sources.
2. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
3. Integral IEEE 62PL device (parallel timing limit relay) for connection to shunt trip on external source circuit breaker.
4. Initiation of No-Interuption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
   a. Controls ensure that closed-transition load transfer closure occurs only when the two sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
5. Failure of power source serving load initiates automatic break-before-make transfer.

C. Withstand Rating Type: Short-Time.
   1. Short-time withstand capability for 30 cycles.

D. Voltage/ Frequency Rating: As indicated in drawings.

E. Configuration Type: 3-pole, 4-wire, solid neutral.

F. Enclosure Type: General-purpose NEMA 250, Type 1 or Type 3R, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

G. Ampere Rating: As indicated in plans.

H. Cable connections accessible via front or rear access.

I. Large-Motor-Load Power Transfer:
   1. Motor Disconnect and Timing Relay Controls: Designated starters in loss of power scenario to disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters to be through wiring external to ATS. Provide adjustable time delay for reconnecting individual motor loads.

2.4 TRANSFER SWITCH ACCESSORIES

A. Remote Annunciator System:
   1. Source Limitations: Same manufacturer as transfer switch in which installed.
   2. Functional Description: Remote annunciator panel to annunciating conditions for indicated transfer switches.
   3. Annunciation panel display to include the following indicators:
      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.

   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.

B. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. 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.

3. Malfunction of annunciator, annunciator and control panel, or communication link will not affect functions of ATS. In the event of failure of communication link, ATS automatically reverts to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function will not depend on remote panel for proper operation.

4. 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.

C. Anti-Condensation Heater: For outdoor installations, provide heater strip, sized by manufacturer supplied inside the transfer switch enclosure and controlled by an adjustable humidistat. Humidistat adjustable from 35 to 95 percent relative humidity, factory set at 65 percent. 120 V(ac) power provided from external source with 15 A protective circuit breaker provided internal to transfer switch.

D. Surge Protection Device (SPD): UL 1449 listed SPD provided for protection of normal source supply with replaceable cartridges to allow replacement of components without disconnecting the normal source supply. 90 dB audible alarm and terminal block for remote alarm contacts provided. SPD to provide L-L, L-N, L-G, and N-G lines protection. LED status indicators integral on the face of the device to indicate operational state.

E. Input/Output Module: Two programmable inputs and six programmable outputs.
1. Inputs:
   a. Contact closure.
   b. Current: 5 mA maximum.
   c. Connection Type: Terminal strip.
   d. Wire Size: 14 to 24 AWG.
   e. Maximum Distance: 700 ft.

2. Outputs:
   a. Contact Type: Form C (SPDT).
   b. Contact Rating: 2 A at 30 V(dc) or 500 mA at 125 V(ac).
   c. Connection Type: Terminal strip.
   d. Wire Size: 14 to 24 AWG.

F. High Current/Voltage I/O Module: Two programmable inputs and three programmable outputs.

1. Inputs:
   a. Contact closure.
   b. Current: 5 mA maximum.
   c. Connection Type: Terminal strip.
   d. Wire Size: 14 to 24 AWG.
   e. Maximum Distance: 700 ft.

2. Outputs:
   a. Contact Type: Form C (SPDT).
   b. Contact Rating: 12 A at 24 V(dc), 12 A at 250 V(ac), 10 A at 277 V(ac), or 2 A at 480 V(ac).
   c. Connection Type: Terminal strip.
   d. Wire Size: 14-24 AWG.

G. External Battery Supply Module: External battery to energize ATS controls when no source power is available, allowing extended engine start time delay. Connecting to one or two batteries, at 12 or 24 V(dc) with integral low external battery voltage indication to the transfer switch controller and reverse-polarity protection.

H. Alarm Module: Integral 90 dB audible alarm horn programmable to activate under user selected fault conditions designated through user interface. Audible alarm continues until manually silenced.

1. Preferred Source Selection for three-source systems.
2. Provides alarming for non-automatic transfer switch equipped with supervised transfer accessory.
3. External alarm signal, rated 500 mA at 120 V(ac) or 250 mA at 240 V(ac). Alarm state continues until alarm condition ends.

I. Load Shed: Factory installed control to force transfer of ATS from Emergency to OFF position.

J. Current Sensing: Measurement and display of load current on all phases with 1 percent accuracy.
K. Digital Meter: Measurement and display of voltage, current, frequency, and power for both sources, including programmable visual alarms for high and low voltage and high current. A serial, RS-485 port and two auxiliary contacts for external connections and password protected programming menus.

L. Engine Start Circuit Monitoring Module: Continuously monitoring for wiring faults (open or short circuits) per the electrical code NEC 700.10.

2.5 SOURCE QUALITY CONTROL

A. For each test required by UL 1008, provide test confirmation from manufacturer for the following conditions:
   a. General - Normal operation.
   b. Overvoltage.
   c. Undervoltage.
   d. Loss of supply voltage.
   e. Reduction of supply voltage.
   f. Alternative supply voltage or frequency is at minimum acceptable values.
   g. Temperature rise.
   h. Dielectric voltage-withstand; before and after short-circuit test.
   i. Overload.
   j. Endurance.
   k. Short circuit Withstand.
   l. Short circuit Close-On.
   m. Short-time current capability.
   n. Insulating base and supports damage.

B. Factory Tests: Test and inspect components, assembled switches, and associated equipment in accordance with UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements.

C. Requires CSA certification option.

D. Perform dielectric strength test complying with UL1008/CSA C22.2-178.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor-Mounting Switch: Anchor to floor by bolting.
   1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
   2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
   3. Provide workspace and clearances required by NFPA 70.
3.2 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, 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.

   1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect twisted pair cable in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

G. Route and brace conductors in accordance with manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

H. Brace and support equipment in accordance with Section 260548.16 "Seismic Controls for Electrical Systems."

I. Final connections to equipment to be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

A. Administrator for Tests and Inspections:
   1. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
B. Tests and Inspections:

1. After installing equipment, test for compliance with requirements in accordance with NETA ATS.
2. Visual and Mechanical Inspection:
   a. Compare equipment nameplate data with Drawings and Specifications.
   b. Inspect physical and mechanical condition.
   c. Inspect anchorage, alignment, grounding, and required clearances.
   d. Verify that the unit is clean.
   e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
   f. Verify that manual transfer warnings are attached and visible.
   g. Verify tightness of all control connections.
   h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
      1) Use of low-resistance ohmmeter.
      2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
   i. Perform manual transfer operation.
   j. Verify positive mechanical interlocking between normal and alternate sources.
   k. Perform visual and mechanical inspection of surge arresters.
   l. Inspect control power transformers.
      1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
      2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
      3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:
   a. Perform insulation-resistance tests on all control wiring with respect to ground.
   b. Perform a contact/ pole-resistance test. Compare measured values with manufacturer's acceptable values.
   c. Verify settings and operation of control devices.
   d. Calibrate and set all relays and timers.
   e. Verify phase rotation, phasing, and synchronized operation.
   f. Perform automatic transfer tests.
   g. Verify correct operation and timing of the following functions:
      1) Normal source voltage-sensing and frequency-sensing relays.
      2) Engine start sequence.
      3) Time delay on transfer.
      4) Alternative source voltage-sensing and frequency-sensing relays.
      5) Automatic transfer operation.
      6) Interlocks and limit switch function.
      7) Time delay and retransfer on normal power restoration.
      8) Engine cool-down and shutdown feature.
   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
   a. Simulate power failures of normal source to ATS and retransfer from emergency source with normal source available.
   b. Verify time-delay settings.
   c. Verify pickup and dropout voltages by data readout or inspection of control settings.
   d. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
   e. 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.

C. Coordinate tests with tests of generator and run them concurrently.

D. 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.

E. Prepare test and inspection reports.

F. 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.
   1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   2. 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.
   3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Training includes testing ground-fault protective devices and instructions to determine when the ground-fault system will be retested. Include instructions on where ground-fault sensors are located
and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.

C. Coordinate this training with that for generator equipment.

END OF SECTION 263600
SECTION 265200
SOLID STATE LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Section includes, but is not necessarily limited to, the furnishing and installation of solid state lighting (SSL) Luminaires (herein referred to as Luminaires) applied to the illumination of interior and exterior spaces. Luminaires shall be listed in accordance with national recognized testing laboratories (NRTLs) approved by the United States Department of Labor, Occupational Safety and Health Administration (OSHA).

1.2 RELATED DOCUMENTS

A. Specification Section 260923 – “Lighting Control Devices”.

1.3 DEFINITIONS AND STANDARDS

A. The terms and standards used or referenced herein are defined as follows:

2. ANSI-C82.11 - American National Standard for Lamp Ballasts – High Frequency Fluorescent Lamp Ballasts.
3. ANSI-C82.SSL1 - SSL Drivers (in ANSI development)
4. CALiPER - Commercially Available LED Product Evaluation and Reporting ‘A’ US DOE program for the testing and monitoring of commercially available LED Luminaires and lights.
5. CCT - Correlated Color Temperature: Visible light characteristic of comparing a light source to a theoretical, heated black body radiator; measured in Kelvin.
7. Fc - foot-candle. Unit of illuminance.
14. IES-TM-21 - Method for determining an LED luminaire or integral replacement lamp’s expected operating life, based on initial performance data collected per IES- LM-80.
15. L80 - The extrapolated life in hours of the luminaire when the luminous output depreciates 20 percent from initial values.
18. NVLAP - National Voluntary Laboratory Accreditation Program. A program under the US DOE to accredit independent testing laboratories to qualify.
19. Power Factor - The ratio of the real power component to the total (complex) power component.
20. Rated power - Power consumption that the luminaire was designed and tested for at ambient temperature.
21. SPD - Surge Protection Device. A subsystem or component(s) that can protect the unit against short duration voltage and current surges.
22. SSL - Solid-State Lighting.
23. THD - Total Harmonic Distortion. The amount of higher frequency power on the power line.

B. Except as herein specified or as indicted on the Drawings, the work of this section shall comply with the following:

1. ANSI-UL Standards
   a. 924 – Emergency Lighting and Power Equipment
   b. C78.377 – Chromacity of Solid State Lighting (SSL) Products
   c. C82.11 – High Frequency Fluorescent Lamp Ballasts
   d. C82.SSL1 – SSL Drivers

2. IEC
   a. EN-61000-6-3 – EMC Emission Standards

3. NFPA
   a. 70-NEC
   b. 101-Life Safety

4. Standards as listed and referenced in this Specification.

1.4 FIXTURE SCHEDULE

A. No substitutions other than the equal manufacturers will be accepted, unless approved in writing by the Engineer. The lighting equipment specified herein has been carefully chosen for its ability to meet luminous performance requirements of this project.

B. This Contractor shall include in his Base Bid spare materials for all lighting fixtures, lamps, and ballast installed on the project. Refer to drawings for additional information regarding spare stock. Turn this equipment over to the Owner at completion of the project. Provide a typewritten label on each fixture with lamp ordering code number for Owner’s future maintenance replacement. Locate label so that it can be seen from normal viewing angle.
C. Once Bids and Shop Drawings are approved, all lighting is to be ordered according to construction schedule and lead times.

1.5 SUBMITTALS

A. Submit shop drawings and manufacturers’ data for the following items in accordance with the conditions of the contract and as specified below.

1. Shop drawings shall be submitted with product datasheets that include the following information:
   
   a. General device descriptions  
   b. Dimensions  
   c. Wiring details  
   d. Nomenclature  
   e. Operating temperature range  
   f. System efficacy  
   g. Rated life  
   h. Rated output  
   i. Input wattage  
   j. Inrush current  
   k. THD  
   l. Power factor  
   m. Warranty  
   n. CCT  
   o. The rated life  
   p. Lumen output

   1) This information shall be provided for the actual lumen package and driver combination specified. Provide information regarding the effects of temperature on the rated life and lumen output. If applicable, the submittal shall also include the US Department of Energy Lighting Facts label.

2. Shop drawings shall include a complete listing of all luminaires on a single sheet. This listing shall contain the luminaire type, manufacturer’s catalog number, applied voltage, and wattage.

1.6 WARRANTY

A. The manufacturer shall provide a warranty against loss of performance and defects in materials, finishes, and workmanship for the Luminaires and all components for a minimum period of 5 years after acceptance of the Luminaires. Replacement Luminaires shall be provided promptly after receipt of Luminaires that have failed at no cost to the customer. All warranty documentation shall be provided to customer prior to random sample testing.

B. Failure of the LED light source shall be defined as failure or negligible output of 10% or more individual LEDs within the LED array, bar, etc.
1.7 PROTECTION

A. Protect lighting fixtures and work against dirt, water or mechanical damage before, during, and after installation. Damage to fixtures prior to final acceptance shall be repaired or replaced at no cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS AND FIXTURES

A. General

1. Provide all lighting fixtures in accordance with Lighting Fixture Schedule and as indicated and required on Drawings.
2. Fixture catalog numbers only indicate type and style. Provide each fixture complete with proper fixture trim, levelers, mounting brackets, flanges, plaster rings, glassware and accessories for complete installation as required for type of ceiling and room finish schedules.
3. Provide each fixture at heliped complete with proper fixture trim, concrete base, levelers, mounting brackets, flanges, plaster rings, glassware and accessories for complete installation as required for outdoor use.
4. All plastic diffusers used in lighting fixtures shall be manufactured of 100 percent virgin acrylic plastic, polycarbonate, or as otherwise noted.
5. Provide approved fireproof enclosures UL rated (UL 0529) where recessed in fire rated ceilings.
6. Provide gaskets as required to prevent light spill between frames and ceilings.
7. Provide “wet” labels on all fixtures installed outdoors or in moist areas.
8. Provide continuity of ground on all fixtures used as raceways and mounted end to end.
9. All metal parts to be chemically treated with a rust resistant phosphatized solution, internal components and reflecting surfaces to have a factor of minimum 90%.
10. Provide luminaires, completely factory-assembled and wired and equipped with necessary light sources, drivers, wiring, shielding, reflectors, channels, lenses, etc., and deliver to job ready for installation.
11. Luminaire Reflector Care: Luminaires with Alzak reflectors shall be installed with Mylar cover over reflectors. Cover shall be UL listed for temporary lighting. Upon completion of work, remove Mylar cover with white glove and blow clean reflectors.
12. Finish: Porcelain or baked enamel finish matte white on interiors with minimum test reflectance of 90% matte white finish or as specified in visible exterior. Thoroughly clean base metal and bonderize after fabrication.
13. Where utilized as raceway, luminaires shall be suitable for use as raceways. Provide feed through splice boxes where necessary. Wiring shall be rated for 90 degrees Centigrade.

B. Luminaires:

1. Each luminaire shall consist of an assembly that utilizes LEDs as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply). If required, components such as the LED array and driver shall be modular and replaceable without removing the luminaire.
2. Each luminaire shall be rated for a minimum operational life as specified on lighting fixture schedule or per basis of design luminaire, as defined by IES LM-80 and TM-21.
3. Each luminaire shall be designed to operate at an average operating temperature of 25°C.
   a. The typical operating temperature range shall be -10°C to +25°C, unless otherwise specified on lighting fixture schedule and Drawings.
   b. Some parameters and tests (such as IESNA standard LM-80-08) shall be conducted at different ambient temperatures.

4. Each luminaire shall meet all parameters of this specification throughout the minimum operational life when operated within the rated temperature range.

5. The individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.

6. Each luminaire shall be listed with a nationally recognized testing laboratory (including but not limited to UL, CSA, ETL) under UL 1598 and UL 8750, or an equivalent standard from a recognized testing laboratory.

C. LEDs:

1. The light source of the luminaires shall consist of LED arrays or bars. If required, the LED arrays or bars shall be removable.
2. The LEDs shall be either white or RGB, according to the light fixture schedule and Drawings. For luminaires specified with white light, it is not acceptable to provide RGB LEDs mixed to produce white light.
3. Refer to the light fixture schedule and Drawings for the specified correlated color temperature (CCT) of each luminaire.
4. Individual LEDs shall be binned by manufacturer to comply with ANSI C78.377.
5. The LEDs shall be manufactured by Cree, Philips, Toshiba, Osram, Samsung, or Nichia, unless otherwise noted.

D. Drivers:

1. The driver or power supply for the luminaire shall be modular and replaceable.
2. The rated life of the driver shall match the rated life of the LEDs and luminaire.
3. In general, the drive current rating of the driver shall be minimized, while still maintaining the required lumen output, to improve luminaire efficiency and life.
4. The driver shall meet the emission standards of IEC EN-61000-6-3 at a minimum. For healthcare or other applications with EMI sensitive equipment, provide drivers that meet more stringent standards as required.

E. Exit Lighting

1. Exit lighting system shall be as indicated on Drawings.
2. Equipment shall be complete with LED light sources.
3. Where indicated as such, provide battery pack and charger with self-diagnostics for illumination under power failure conditions.
4. Equipment shall meet BOCA, OSHA, NFPA and NEC illumination standards.

2.2 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel and angle-iron supports and nonmetallic channel and angle supports.

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B. Single-Stem Hangers: ½ inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, ½ inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

PART 3 - TECHNICAL REQUIREMENTS

3.1 ELECTRICAL

A. Power Consumption: Maximum power consumption allowed for the luminaire shall be per basis of design light fixture listed on lighting fixture schedule.

B. Operation Voltage

1. The luminaire shall operate from a 60 HZ ±3 HZ AC line over a voltage ranging from 110 VAC to 277 VAC as specified on the drawings. The fluctuations of line voltage shall have no visible effect on the luminous output.
2. The standard operating voltages are as shown on drawings.

C. Current: The inrush current for the luminaire shall be published on the luminaire data sheet and shall be less than that of the basis of design fixture listed on the light fixture schedule.

D. Power Factor: The luminaire shall have a power factor of 0.90% or greater at all standard operating voltages.

E. THD: Total harmonic distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 20 percent at any standard input voltage. The luminaire shall comply with ANSI C82.11, or equivalent ANSI LED Standard C82.SSL1.

F. Surge Suppression: The luminaire shall include surge protection to withstand high repetition noise and other interference.

1. The surge protection which may reside within the driver shall protect the luminaire from damage and failure for transient voltages and currents as defined in ANSI/IEEE C64.41 for Location Category A Low. Where failure does not mean a momentary loss of light during the transient event.
2. Surge protection performance shall be tested per the procedures in ANSI/IEEE C62.45 based on ANSI/IEEE C62.41 definitions for standard and optional waveforms for Location Category A-Low.

G. Operational Performance: The LED circuitry shall prevent perceptible flicker to the unaided eye over the voltage range specified above.

H. RF Interference: The luminaire and associated on-board circuitry must meet Class A emission limits referred in IEC EN-61000-6-3 and Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 regulations concerning the emission of electronic noise.
I. Dimming: Where dimming is specified on the drawings, the luminaire shall be capable of continuous dimming without perceivable flicker over a range of 100% to 5% of rated lumen output. Dimming shall be controlled by a 0-10V signal, unless otherwise noted or specified.

1. Dimming switches and other control system components shall be compatible with the LED driver type – constant current reduction (CCR) or pulse-width modulation (PWM). The device(s) shall be rated to accommodate full load, as well as inrush current and repetitive peak currents.
2. The luminaire and dimming controls shall produce a smooth change in lumen output, without any visible flicker.
3. The luminaire shall be capable of dimming without any visible change in CCT and color rendition.

J. Multi-Level Control: Where specified on drawings, the luminaire shall be provided with multiple power supplies, multi-level power supply, or other similar means to facilitate multi-level control of luminaire.

K. Temperature Range: The luminaire shall have the capability of operating and maintaining rated lumen output and rated life within the temperature range specified on the lighting fixture schedule and Drawings, or within that of the basis of design luminaire if no temperature range is specifically listed.

L. Lumen Output and Performance:

1. The luminaire shall maintain the lumen output specified on the lighting fixture schedule and Drawings, or that of the basis of design luminaire if no minimum lumen output is specifically listed.
2. The lumen output shall be maintained regardless of ambient temperature fluctuations, within the rated temperature range. The luminaire data sheets shall specify any effect or variation on lumen output from temperature.
3. The luminaire shall be capable of continuously monitoring system performance to allow for constant lumen management/compensation, if specified in lighting fixture schedule, Drawings, or basis of design luminaire.
4. The luminaire shall provide a total system efficacy that meets or exceeds that of the basis of design luminaire listed on the light fixture schedule and Drawings.

M. Rated Life: The luminaire shall have a rated life that meets or exceeds that listed on the lighting fixture schedule and Drawings, or that of the basis of design luminaire if no rated life is specifically listed.

3.2 PHOTOMETRIC REQUIREMENTS

A. Light Output

1. The minimum initial lumen output of the luminaire exiting the luminaire in the 0-90 degree zone - as measured by IESNA Standard LM-79-08 shall be as specified in the lighting fixture schedule and Drawings, or that of the basis of design luminaire if no lumen output is specifically listed.
2. The lumen output shall not decrease by more than 30% over the minimum operational life (or L70 shall be at least the minimum number of hours specified).
3. The measurements shall be calibrated to standard photopic calibrations.

B. Light Color/Quality.

1. Corrected Color temperature (CCT) range shall be correlated to chromaticity as defined by the absolute (X,Y) coordinates on the 2-D CIE chromaticity chart.
2. The color rendition index (CRI) shall be 80 or greater for interior applications, and 70 or greater for exterior applications.

3.3 THERMAL MANAGEMENT

A. The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to assure proper operation of the luminaire over the expected useful life.

1. The LED manufacturer’s maximum junction temperature for the expected life shall not be exceeded at the average operating ambient.
2. The LED manufacturer’s maximum junction temperature for the catastrophic failure shall not be exceeded at the maximum operating ambient.
3. The luminaire shall have an UL/IC rating, if applicable.

B. The Driver manufacturer’s maximum case temperature shall not be exceeded at the maximum operating ambient. Thermal management shall be passive by design.

1. The use of fans or other mechanical devices shall not be allowed.

3.4 PHYSICAL AND MECHANICAL REQUIREMENTS

A. The luminaire shall be a single, self-contained device, not requiring on-site assembly for installation. The power supply for the luminaire shall be integral to the unit, unless otherwise specified.

B. The assembly and manufacturing process for the SSL luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.

C. The optical assembly of the luminaire shall be constructed so that individual LED images shall not be visible to the occupant.

D. The electronics/power supply enclosure shall be internal to the SSL luminaire and be accessible per UL requirements.

E. The circuit board and power supply shall be contained inside the luminaire.

F. Electrical connections between normal power, driver and LED boards must be modular utilizing a snap fit connector. All electrical components must be easily accessible after installation from the room side and all electrical components must to be able to be replaced without removing the fixture from the ceiling.

G. For LED retrofit lamps, the weight of the unit shall be in compliance with weight ratings of the lamp sockets/bases.
3.5 MATERIALS

A. Housings shall be fabricated from material indicated on lighting fixture schedule.

B. If applicable, refractor or lens shall be made from UV inhibited high impact plastic (such as acrylic or polycarbonate) or heat and impact resistant glass.

C. If applicable, polymeric materials of enclosures containing either the power supply or electronic components of the luminaire shall be made of UL94VO flame retardant materials. The lenses of the luminaire are excluded from this requirement.

3.6 LUMINAIRE IDENTIFICATION

A. Each luminaire shall have the manufacturer's name, trademark, model number, serial number, date of manufacture (month-year), and lot number as identification permanently marked inside the each unit and the outside of each packaging box.

B. The following operating characteristics shall be permanently marked inside each unit: rated voltage and rated power in Watts and Volt-Ampere.

C. Provide identification mark for fixtures wired to emergency backup systems. Coordinate with Project Manager.

3.7 QUALITY ASSURANCE

A. The luminaires shall be manufactured in accordance with a manufacturer quality assurance (QA) program. The QA program shall include two types of quality assurance: (1) design quality assurance and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of the modules built to meet this specification, and a documented process of how problems are to be resolved.

B. QA process and test results documentation shall be kept on file for a minimum period of seven years.

C. LED luminaire designs not satisfying design qualification testing and the production quality assurance testing performance requirements described below shall not be labeled, advertised, or sold as conforming to this specification.

D. DESIGN QUALIFICATION TESTING

1. Design Qualification Testing shall be performed by a National Voluntary Laboratory Accreditation Program (NVLAP) testing facility. Such testing may be performed by the manufacturer or an independent testing lab hired by the manufacturer on new luminaire designs, and when a major design change has been implemented on an existing design. A major design change is defined as a design change (electrical or physical) which changes any of the performance characteristics of the luminaire, results in a different circuit configuration for the power supply, or changes the layout of the individual LED's in the module.

2. A quantity of two units for each design shall be submitted for Design Qualification Testing.
3. Product submittals shall be accompanied by product specification sheets or other documentation that includes the designed parameters as detailed in this specification. These parameters include (but not limited to):

4. Maximum power in Watts
5. Maximum Designed Junction Temperature
6. L70 in hours, when extrapolated for the average operating temperature
7. Product submittals shall be accompanied by performance data that is derived in accordance with appropriate IESNA testing standards and tested in a laboratory that is NVLAP accredited for Energy Efficient Lighting Products.
8. Product submittals shall be accompanied by a test report showing surge protection performance as tested per the definitions and procedures in ANSI/IEEE C62.411991
9. Thermal testing data and reporting shall be provided based on the sensor input as defined below:
   a. Temperature sensors shall be mounted on the LED solder pads as close to the LED as possible.

10. Burn-In: Before any customer design qualification testing is performed, the sample Luminaires shall be energized for a minimum of 24 hours, at 100 percent on-time duty cycle, at a temperature of +70°F (+21°C).
11. Any failure of the luminaire, which renders the unit non-compliant with the specification after burn-in, shall be cause for rejection.
12. The luminaire shall be tested as described herein.
   a. Luminaire performance shall be judged against the specified minimum illuminance in the specified pattern for a particular application.
   b. The luminaire lighting performance shall be adjusted (depreciated) for the minimum life expectancy.
      1) The performance shall be adjusted (depreciated) by using the LED manufacturer's data or the data from the IESNA Standard LM-80-08 test report, which every one results in a higher level of lumen depreciation.
   c. The luminaire may be determined to be compliant photometrically, if:
      1) The initial minimum illuminance level is achieved in 100% of the area of the specified lighting pattern, and
      2) The depreciated minimum illuminance is maintained in at least 95% of the area of the specified lighting pattern, and
      3) The minimum length of the depreciated iso-footcandle curve is equal or greater than the length of the specified iso-footcandle curve.

3.8 QUALITY ASSURANCE TESTING (RANDOM SAMPLE TESTING)

A. Random sample testing may be performed on all shipments.

B. Testing shall be completed within 30 days.

C. All parameters of the specification may be tested on the shipment sample.
PART 4 - EXECUTION

4.1 INSPECTION AND PREPARATION

A. General

1. Install outlets, surface mounted, recessed or semi-recessed fixtures to maintain the alignment, spacings, layout and general arrangements indicated in the Drawings. Obtain approval of Engineer for all changes in layout required to avoid interferences with other trades.
2. Install one light fixture of each type and mounting for approval of Owner and Engineer prior to mounting all light fixtures.

B. Coordination

1. Work incorporating with ceiling trades in locating and framing recessed fixtures in acoustical tile pattern or grid system to conform to layout.
2. Inform affected trades of the location and framing details necessary for the installation of flush fixtures and deliver all framing rings of these fixtures that become a part of the ceiling construction.
3. Before equipment is ordered, electrical contractor to review luminaire and ceiling mechanical compatibility in each area and verify luminaire on the drawings. Contractor shall be responsible for all fixture quantities, lengths and clearances required and shall inform the Owner of the job conditions at variance with the fixture(s) specified or detailed which affect installation or location. (All stages of installation.)
4. Mechanical and electrical contractors are to review and coordinate lighting locations in relationship to mechanical systems to minimize conflicts prior to installation.
5. This contractor is responsible for coordinating the characteristics and the U.L. labeling of the luminaires and their components with the ambient conditions, which will exist when the luminaires are installed. No extra compensation will be permitted for failure to coordinate the luminaires with their ambient conditions.

C. Mounting and Supports

1. Install luminaires in mechanical and unfinished areas after ductwork and piping installation.
2. Where luminaires are surface mounted, they shall be labeled for such and a minimum of one-half (1/2) inch air space and shall be maintained between top of luminaire and mounting surface by an approved means.
3. Pendant mounted units shall comply with the following:

   a. Where luminaires are mounted in a continuous row, luminaires, eight feet in length shall have stems placed within 2'-0" of end of fixture. Stems shall be spaced symmetrically. A fixture, four feet or three feet in length, placed in a row, shall have a stem connected to center luminaire.
   b. Individual luminaires, four feet in length, shall have two stems placed approximately 3 inches from each end.
   c. Individual luminaire, three feet in length, shall have dual stems and a single canopy.
   d. Each stem shall have a brass or steel swivel or other self-aligning device of type approved by the Engineer.
4. Where luminaires are mounted on surface-mounted outlet boxes in surface mounted conduit runs, this Contractor shall furnish and install a luminaire canopy sufficiently deep to permit exposed conduits to pass through. Canopy shall have proper openings cut by luminaire manufacturer through which conduits may pass. Submit sample of canopy for approval before installation.

5. Prior to final payment, this contractor shall clean all luminaires and replace any burned out LED modules. He shall also touch up all scratch marks, etc. in an approved manner.

6. Provide a minimum of two support points for all surface, pendant or recessed mounted luminaires. The supports shall be tied to the building structural system. The support points shall be totally independent of the ceiling system.

7. Recessed luminaires to be installed in metal panel or acoustic modular ceilings shall be modified as required to fit into openings in ceiling construction. Shop Drawings showing details shall be submitted for approval.

8. Provide each fixture at helipad complete with proper fixture trim, concrete base, levelers, mounting brackets, flanges, plaster rings, glassware and accessories for complete installation as required for outdoor use and by manufacturer recommendations.

D. Emergency Systems Raceway and Hook-up

1. Circuit wiring for the emergency systems shall be installed in separate raceway and kept entirely independent of all other wiring and equipment.

4.2 ADJUSTING AND CLEANING

A. At project completion, before final approval:

1. Aim adjustable fixtures as directed by Engineer and observe and adjust at night as required.
2. Clean interior of all fixtures, all lenses and LED modules.

END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
3. System smoke detectors.
4. Non-system smoke detectors.
5. Heat detectors.
7. Firefighters' two-way telephone communication service.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.

1.3 DEFINITIONS

A. LED: Light-emitting diode.


1.4 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

B. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.
1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces.

1.6 SUBMITTALS

A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
   a. Trained and certified by manufacturer in fire-alarm system design.
   b. NICET-certified fire-alarm technician, Level III minimum.
   c. Licensed or certified by authorities having jurisdiction.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. 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.
5. 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.
6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. 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.

1. 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.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
E. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
   a. Frequency of testing of installed components.
   b. Frequency of inspection of installed components.
   c. Requirements and recommendations related to results of maintenance.
   d. Manufacturer's user training manuals.
5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

F. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.

C. 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.

D. 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. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

G. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FMG-approved alarm company.
H. NFPA Certification: Obtain certification according to NFPA 72 by.

1.8 PROJECT CONDITIONS
A. 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:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of fire-alarm service.
2. Do not proceed with interruption of fire-alarm service without Construction Manager's written permission.

1.9 SEQUENCING AND SCHEDULING
A. 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.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.10 SOFTWARE SERVICE AGREEMENT
A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. 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.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 EXTRA MATERIALS
A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
3. Smoke Detectors, Fire Detectors, and Flame Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools: One extra set for access to locked and tamper-proofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Fire Control Instruments, Inc.; a Honeywell company.
2. Fire Lite Alarms; a Honeywell company.
3. Gamewell; a Honeywell company.
4. NOTIFIER; a Honeywell company.
5. Silent Knight; a Honeywell company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices:

2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Automatic sprinkler system water flow.
6. Heat detectors in elevator shaft and pit.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances.
2. Identify alarm at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Activate stairwell and elevator-shaft pressurization systems.
8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
10. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
10. Low-air-pressure switch operation on a dry-pipe or pre-action sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciator at fire-alarm control unit and remote annunciators.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   a. 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.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.
2. Addressable initiation devices that communicate device identity and status.
3. Addressable control circuits for operation of mechanical equipment.

B. 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.

1. Annunciator and Display: Liquid-crystal type, 1 line 40 characters, minimum.
2. 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.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   a. Initiating Device Circuits: Style D.
b. Notification Appliance Circuits: Style Z.
c. Signaling Line Circuits: Style 2.
d. Install no more than 50 addressable devices on each signaling line circuit.

2. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.
   a. Initiating Device Circuits: Style A.
   b. Notification Appliance Circuits: Style W.
   c. Signaling Line Circuits: Style 0.5.
   d. Install no more than 50 addressable devices on each signaling line circuit.


D. 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.

   1. Pressurization starts when any alarm is received at fire-alarm control unit.
   2. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.

E. Smoke-Alarm Verification:

   1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
   2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
   3. Record events by the system printer.
   4. Sound general alarm if the alarm is verified.
   5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification Appliance Circuit: Operation shall sound in a temporal pattern complying with ANSI S3.41.1

G. Elevator Recall:

   1. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall.
      a. Elevator lobby detectors except the lobby detector on the designated floor.
      b. Smoke detector in elevator machine room.
      c. Smoke detectors in elevator hoistway.

   2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.

   3. 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.
a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.

I. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

J. 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 shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.


L. 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.

2.4 MANUAL FIRE-ALARM BOXES

A. 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.

1. Single-action mechanism, breaking-glass type. With integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

2. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

3. Station Reset: Key- or wrench-operated switch.

4. 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.

5. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. 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.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.

B. Photoelectric Smoke Detectors:

1. 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.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

C. Ionization Smoke Detector:

1. 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.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. 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.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit. Verify with Mechanical Drawings and specifications that shutdown in subparagraph below is required; if not required, delete subparagraph.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
   1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F.
   1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. 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.

B. 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.
   1. 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.

C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

E. 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 from the horn, using the coded signal prescribed in UL 464 test protocol.

F. 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 high letters on the lens.

1. Rated Light Output:
   a. 75 cd.
   b. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.
3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.

2.8 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.
4. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR

A. 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.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. 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.

2.10 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. 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.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one or two 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 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.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address Zone of the supervisory signal.
3. Address Zone of the trouble-initiating device.
4. Loss of ac supply or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.
2. Finish: Paint of color to match the protected device.
PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than 72 inches above the finished floor.

C. Smoke- or Heat-Detector Spacing:

3. Smooth ceiling spacing shall not exceed 30 feet.
4. 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.
5. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.

D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

F. 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.

G. 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.

H. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

I. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

K. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

L. Annunciator: Install with top of panel not more than 72 inches above the finished floor.
M. 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) wind load with a gust factor of 1.3 without damage.

3.2 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.3 GROUNDING

A. 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.

3.4 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by Architect and authorities having jurisdiction.

B. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
   a. 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.
   b. 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.


3. 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.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.

5. Test visible appliances for the public operating mode according to manufacturer's written instructions.


C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. 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.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.
SECTION 312000

EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Excavating and backfilling for buildings and structures.

B. Refer to Oklahoma Department of Transportation Standard Specifications, 2019 and subsequent revisions and special provisions for the following:
   1. Excavating and filling for rough grading the Site.
   2. Preparing subgrades for slabs-on-grade, walks, pavements, and preparation for planting areas.
   3. Drainage course for concrete slabs-on-grade.
   4. Subbase course for concrete walks and pavements.
   5. Subbase course for asphalt paving.
   6. Excavating and backfilling trenches for utilities and pits for buried utility structures.

1.2 DEFINITIONS

A. Backfill: Soil material used to fill an excavation.

B. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

C. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

D. Aggregate Base Course: Aggregate layer below building slabs.

E. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
   2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

F. Fill: Soil materials used to raise existing grades.

G. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
H. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

1.3 INFORMATIONAL SUBMITTALS

A. Material test reports.

1.4 FIELD CONDITIONS

A. Utility Locator Service: Notify utility locator service for area where Project is located before beginning earth-moving operations.

B. Do not commence earth-moving operations until plant-protection measures are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
   1. Liquid Limit: 40 Maximum.
   2. Plasticity Index: 8 to 18.

C. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940/D 2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

D. Base Course (below building slabs): Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand meeting the following requirements:
   1. Percent passing 1 1/2" sieve = 100.
   2. Percent passing the No. 200 sieve = 15 or less.
   3. Plasticity index = 6 or less.

E. Engineered Fill: Naturally or artificially graded mixture of non-plastic to fairly low plasticity sandy-clay, clayey-sand or silty-sand meeting the following requirements:
   1. Percent finer than 3-inch sieve = 100
   2. Percent finer than No. 200 sieve = 12 minimum; if PI ≤ 7, 60 maximum.
   3. Liquid limit = 40 maximum.
   4. Plasticity index = 17 maximum.

F. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.
2.2 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored to comply with local practice or requirements of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
   1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.

3.3 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
   1. Excavations for Footings and Slabs on Grade: Footings and Slabs on Grade are placed on engineered fill meeting the requirements in paragraph 2.1E above. The excavation requirements for the site are as follows:
      a. Excavate to a minimum of (3) three feet and (6) six inches below the base of the slab on grade.

3.4 SUBGRADE INSPECTION

A. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired dump truck to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.5 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi, may be used when approved by Architect.

3.6 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
   1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.7 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in maximum 8” layers to required elevations as follows:
   1. Under grass and planted areas, use satisfactory soil material.
   2. Under walks and pavements, use satisfactory soil material.
   3. Under steps and ramps, use engineered fill.
   4. Under building slabs, use engineered fill.
   5. Under footings and foundations, use engineered fill.

3.8 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
   1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
   2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.9 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.
C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:
   1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.

3.10 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

B. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.11 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-SLAVE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
   1. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
   2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.12 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform inspections:

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.13 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.14 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION
SECTION 412233

HOISTS, TROLLEYS, AND MONORAILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hoists, trolleys, and monorails.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.

2. Division 01 - General Requirements.

1.2 QUALITY ASSURANCE

C. Applicable Standards:

1. CMAA Specification #74 or latest revision.

2. AWS D14.1 Welding of Industrial Cranes

3. CFR 1910.179 Overhead & Gantry Cranes (OSHA)

4. American Society of Mechanical Engineers (ASME):
   a. ASME B30.17 and ASME B30.2.

5. ASTM International (ASTM):

   a. 70, National Electrical Code (NEC).

1.2 WARRANTY

A. Warranty for Crane System: Manufacturer agrees to repair or replace components of crane installation that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 2 years or length of the manufacturer warranty, whichever is longest, from date of successful load test. Warranty includes 2 years labor allowance.
1.3 DEFINITIONS

B. Hook Height: The minimum acceptable distance in feet from bottom of hook in full raised position to the nearest floor surface.

C. Lift Height: The distance in feet from the bottom of the hook in full raised position to the surface of the lowest floor from which items may be hoisted.

D. Total Trolley Capacity: The ultimate load-carrying capacity of the trolley based on the ultimate strength of the material used (with a 5:1 safety factor) and the bearing life.

E. Ultimate Load-Carrying Capacity: Live load, weights of all equipment and an allowance for impact.

1.4 SUBMITTALS

F. Shop Drawings:

   1. See Specification Section 013300 for requirements for the mechanics and administration of the submittal process.

   2. Product technical data including:

      a. Acknowledgement that products submitted meet requirements of standards referenced.

      b. Shop drawings shall include all applicable weights, dimensions, and reactions.

   3. Fabrication and/or layout drawings.

      a. Track layout including supports, splices, connections, switches, and end trucks.

   4. Test reports verifying strength of inserts and rail.

   5. Load test results.

G. Contract Closeout Information:

   1. Operation and Maintenance Data:


      b. Upon completion of the project, the crane vendor shall submit final as-built drawings stamped by a registered Professional Engineer licensed in the state of Oklahoma.

      c. Crane vendor shall provide Operator and Maintenance training consisting of classroom and field training up to 4 hours.
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

H. Crane manufacturer must provide service operations within the Tulsa metro area to provide emergency response as needed.

I. Crane manufacturer must provide proof of business under same name for the past 5 years.

J. All manufacturers must be pre-approved prior to bidding. Pre-approval shall be submitted on standard CSI substitution request form.

K. Submit request for substitution in accordance with Specification Section 012500.

2.2 MANUFACTURED UNITS

L. Crane General:

1. Type: Under running single girder-structural construction designed to L/600 deflection criteria. Safety yellow paint.

2. Capacity: 2 tons (4,000#)

3. Bridge Speed: 25 – 100 FPM via variable frequency drive

4. End Trucks: Dual drive with machined steel or SGCI wheels/bridge girder to end truck connection is via a bolted style connection plate.

5. Bridge Electrification: Flat cable festoon system featuring trollies with steel wheels, mounting hardware and appropriate flat cable.

6. Control Pendant: Radio remote control system
   a. Two (2) handheld transmitters
   b. One (1) crane mounted receiver
   c. Operational strobe light
   d. Audible alarm
   e. A sliding pendant suspended from a separate festoon track must be supplied as a back-up.

7. Span: 38'-0" + 1'-0" overhang at each end

8. Duty Classification for crane: Class C.


M. Hoists:

1. Electric Chain Hoist:
a. Upper and lower travel limit switch

b. Weight overload limit device

c. Chain container

d. Single chain fall to lower load block

e. Type: Standard headroom/motor driven trolley

f. Capacity: 2 tons (4,000#)

g. Lift: 16’-2” available

h. Hoist speed: 4 & 16 +/- FPM two speed

i. Trolley Speed: 26 & 55 +/- FPM two speed

j. Duty Classification for hoist: H4

k. Power Supply: 230v/3ph/60hz

2. Mark each hoist with the following information:

   a. Name and address of manufacturer.

   b. Manufacturer’s unit identification number.

   c. Rated load.

N. Runway System:

1. The runway system shall be provided by the crane manufacturer. The runway system shall include the runway beams, splice plates, electrification brackets, electrification, hi-strength connection bolts, medium grey paint and bolted end stops.

2. Runway Beams: shall be supported from support brackets to be provided by the pre-engineered building manufacturer.

   a. Designed to accommodate one (1) at 2 tons capacity URSG crane per support space at max capacity.

   b. Runway beam length: Two (2) at 50’-0” each.

3. The support brackets shall feature four (4) slotted holes suitable for use with 5/8” structural bolts.

4. The support bracket shall be provided and installed by the pre-engineered metal building manufacturer. Install straight, level, and paralleled to CMAA specifications.

5. Electrification: Lateral Mounted 40 amp rated enclosed 4 conductor system.
a. Basis of design: Vahle KBH or Magnetek ELECTROBAR Elite or approved equal.

6. Power Supply: 230v/3ph/60hz at 30 amps

7. Max Support Spacing: 25'-0"

8. Switches:

a. Bridge travel limit switch (one step) that will move the crane to the low speed at the end of the runway system prior to engagement of the runway end stop.

b. Operational strobe light located on the bridge crane.

c. Upper and lower hoist travel limit switches.

d. Weight overload limit device.

e. Trolley travel limit switch (one step) that will move the trolley to low speed at the end of the bridge prior to engagement of the bridge girder end stop.

**PART 3 - EXECUTION**

3.1 INSTALLATION

O. Installation of the crane/hoist, runway system and electrification shall be carried out by the crane vendor’s in-house crews. The crane system shall be installed to CMAA/AISC tolerances for straight, square, and level.

P. Installation of runway beams as shown on Drawings.

Q. Installation of runway beams, system electrification, crane hoists shall be coordinated with Architect prior to installation.

R. Install runway beams to CMAA tolerances, Table 1.4.1-1.

S. Warning Signs:

1. Affix to the hoist or the lower load block or the controls in a readable position a durable label or labels displaying the following information concerning safe operating procedures:

   a. The word WARNING or other legend designed to bring the label to the attention of an operator.

   b. Cautionary language against:

      1) Lifting more than rated load.
      2) Operating hoist when hook is not centered under hoist.
      3) Operating hoist with twisted, kinked or damaged rope or chain.
      4) Operating damaged or malfunctioning hoist.
      5) Operating hoist with a rope that is not properly seated in its groove (if applicable).
      6) Lifting people or lifting loads over people.
7) Removing or obscuring warning label.

3.2 FIELD QUALITY CONTROL

T. Field testing of the crane/hoist throughout the system without test loads. The test shall conform to ASME section B30.17-2.2 and ASME section B30.2-2.2.

U. Field testing by crane provider of the crane/hoist throughout the system with test loads. The test shall conform to ASME section B30.17-2.2 and ASME section B30.2-2.2

3.3 SCHEDULE

V. Hoist, trolley, and monorail systems include but are not necessarily limited to the following:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>LOADING (TONS)</th>
<th>HOIST</th>
<th>TROLLEY</th>
<th>HOOK HEIGHT (FT)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hangar</td>
<td>2</td>
<td>EC</td>
<td>Motor Driven</td>
<td>16'-2&quot;</td>
</tr>
</tbody>
</table>

W. * Distances listed are approximate as they will vary depending on hoist and trolley selection.

1. C = Chain
2. HG = Hand Geared
3. WR = Wire Rope
4. EC = Electric Chain
5. NA = Not Applicable

END OF SECTION