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SECTION 220500 - COMMON WORK FOR PLUMBING

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. Requirements under this section include required work that is common to multiple sections in Division 22 and shall be complied with by all suppliers and subcontractors.

B. This Section includes the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
7. Equipment installation requirements common to equipment sections.
8. Painting and finishing.
9. Concrete bases.
10. Thermometers.
12. Test plugs.
15. Pipe Labels.
16. Valve Tags.
17. Motors.
18. Vibration and Seismic Control.
19. Fixture Supports.

1.3 DEFINITIONS

A. A/E: Prime design consultant responsible for preparation of these specifications.

B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

F. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

G. The following are industry abbreviations for plastic materials:

2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

H. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Provide submittals per Section 013300 “Submittal Procedures.”

B. Product Data: Submit product data for each type of product indicated herein. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Provide for the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
7. Thermometers.
8. Gages.
9. Test plugs.
13. Valve Tags.
15. Valve Schedules: For each piping system to include in maintenance manuals.
17. Fixture Supports.
D. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

E. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression piping.
2. Domestic water piping.
3. Waste and vent piping.
4. Storm Drainage piping.
5. Compressed air piping.
6. HVAC ductwork.
7. Light Fixtures.
8. Cable Trays.
9. Other ceiling mounted devices.

F. Operation and Maintenance Data:

1. All valves and specialty valves,
2. Water piping system accessories, strainers, expansion tanks, meters, backflow preventers, gages, thermometers, trap primers, filters,
3. Drainage specialties, back water valves, drains, interceptors.
4. All equipment that includes an electrical connection and/or has recommended maintenance, along with all related accessories.
5. All controls.

1.5 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 PROJECT CONDITIONS

A. Do not install products or materials that are wet, moisture damaged, or mold damaged.

B. Field Measurements: Verify actual dimensions of site conditions by field measurements before fabrication.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect piping from end damage and to prevent debris from entering pipe. Maintain piping through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 TRANSITIONS AND OFFSETS BEYOND THE SCOPE OF WORK

A. Check drawings of other trades to verify spaces in which work will be installed. Establish exact locations of piping and ducts in such a manner as to conform to structure, avoid obstructions, and keep openings and passageways clear. Lines that must pitch, or that must have a constant elevation, shall have the right-of-way over lines not so restricted. Maintain maximum headroom. If space conditions appear inadequate, notify the A/E before proceeding with the work. Make reasonable modifications in the work without extra cost as needed to prevent conflict with work of other trades and for proper execution of the work.

1.9 COORDINATION

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

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Section 083113 "Access Doors and Frames."

D. Coordinate work with other trades including venting, electrical connections, gas service, equipment connections, controls, etc.

E. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:

1. Motor controllers.
2. Torque, speed, and horsepower requirements of the load.
3. Ratings and characteristics of supply circuit and required control sequence.
4. Ambient and environmental conditions of installation location.

F. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

G. Coordinate installation of identifying devices with locations of access panels and doors.

H. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8-inch-thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D 2235.
2. CPVC Piping: ASTM F 493.
3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
4. PVC to ABS Piping Transition: ASTM D 3138.

I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
2. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
3. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Waterway Fittings:
   1. Piping 2" Size and Smaller: Provide at each point of connection between copper and galvanized steel pipe, dielectric waterway design, threaded, lined with inert, non-corrosive thermoplastic.
   3. Manufacturers:
      a. Clearflow.
      b. Epco Sales, Inc.
      c. Watts

D. Dielectric Flanges:
   1. Flanges in Copper Piping: Bronze or wrought-copper companion flange with tubing shoulder, 150-lb. or 300-lb wsp rating, as required to suit system pressure, with 1/16-inch thick red rubber gasket per ANSI/ASME B16.21.
   3. Manufacturers:
      a. Clearflow.
      b. Epco Sales, Inc.
      c. Watts

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
   1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
   2. Basis of Design: PSI Pipeline Seal and Insulator, Inc. Dielectric Flange Kit.
   3. Manufacturers:
      a. Advance Products and Systems.
      b. Calpico Inc.
      c. PSI Pipeline Seal and Insulator, Inc.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225-degree F. Calpico, Inc. or Lochinvar Corp "V-Line".

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225-degree F.
2. Manufacturers:
   a. Precision Plumbing Products, Inc.
   b. Sioux Chief,

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Stainless steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.
E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.
2.8 ESCUTCHEONS

A. General: Provide all steel manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening. All escutcheons shall have polished chrome plated finish. Provide deep pattern escutcheons where needed to conceal couplings and fittings that protrude beyond the wall surface. No split ring escutcheons, no plastic escutcheons.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, non-shrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.

2.10 THERMOMETERS AND PRESSURE GAGES


1. Manufacturers:
   b. Trerice, H. O. Co.
   c. Weiss Instruments, Inc.
   d. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

2. Case: Highly polished, hermetically sealed, stainless steel with five-inch diameter.
4. Element: Bimetal coil.
5. Dial: Satin-faced, or highly polished, non-reflective aluminum with permanently etched scale markings.
7. Window: Double strength Glass.
9. Stem: stainless steel, for thermo-well installation and of length to suit installation.
10. Accuracy: Plus or minus one percent of range or plus or minus one scale division to maximum of 1.5 percent of range. Scale shall be degrees Fahrenheit, unless otherwise indicated, suitable for the media operating temperatures.
11. Thermometers shall conform generally to the following:

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<td>2</td>
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<td>Domestic cold water</td>
<td>30-130</td>
<td>1</td>
</tr>
<tr>
<td>Non-potable hot water</td>
<td>0-250</td>
<td>2</td>
</tr>
<tr>
<td>Non-potable cold water</td>
<td>30-130</td>
<td>1</td>
</tr>
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B. Thermowells: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer with extension necks of suitable length for insulated piping. Furnished by same manufacturer as thermometers.

C. Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Manufacturers:
   b. Trerice, H. O. Co.
   c. Weiss Instruments, Inc.
   d. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

2. Case: Liquid-filled type, 4-1/2-inch diameter Grade A Phosphor Bronze.
3. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
4. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Ring: Stainless steel.
10. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
11. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
12. Range for Fluids under Pressure: Two times operating pressure.
13. Scale: Scale shall be psig or inches mercury vacuum depending on the application.

D. Shutoff Cocks for Gauges: 1/4" NPT lever handle ball valve with solid chrome-plated brass ball. Same manufacturer as gauge.

E. Pressure Snubbers: Filter type snubbing element, brass housing. Same manufacturer as gauge.

2.11 TEST PLUGS

A. Manufacturers

1. MG Piping Products Co.
2. Sisco Manufacturing Co.
3. Trerice, H. O. Co.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem beyond insulation for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

D. Core Inserts: One or two self-sealing neoprene, valves gasketed orifice, suitable for inserting a 1/8” OD probe assembly.
1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

E. Test Kit: Furnish one test kit containing one pressure gage and adaptor, one thermometer, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 3-inch diameter dial and probe. Dial range shall be 0 to 200 psig.
2. High-Range Thermometer: Small bimetallic insertion type with 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
3. Carrying case shall have formed instrument padding.

2.12 HEAT TRACING

A. General: Complete heat tracing systems shall be provided where indicated for plumbing piping.

B. Self-Regulating, Parallel-Resistance Heating Cables:

1. Manufacturers:
   a. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
   b. Delta-Therm Corporation.
   c. Raychem; a division of Tyco Thermal Controls.

2. Heating Element: Pair of parallel No. 16 AWG, stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.


4. Cable Cover Stainless-steel braid and polyolefin outer jacket with UV inhibitor.

5. Maximum Operating Temperature (Power On): 150 deg F.

6. Maximum Exposure Temperature (Power Off): 185 deg F.

7. Maximum Operating Temperature: 300 deg F.

C. Controls:

1. Pipe-Mounting Thermostats for Freeze Protection:
   a. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.
   b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
   c. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
   d. Corrosion-resistant, waterproof control enclosure.
2. Programmable Timer for Domestic Hot-Water-Temperature Maintenance:
   a. Microprocessor based.
   b. Minimum of four separate schedules.
   c. Minimum 24-hour battery carryover.
   d. On-off-auto switch.
   e. 365-day calendar with 20 programmable holidays.
   f. Relays with contacts to indicate operational status, on or off, and for interface with central HVAC control system workstation.

D. Accessories:
   1. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
   2. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

2.13 IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
   4. Maximum Temperature: Able to withstand temperatures up to 160-degree F.
   5. Minimum Label Size: Length and width vary for required label content, size labeling as appropriate for pipe size.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

D. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

F. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

G. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
   1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Fasteners: Brass beaded chain; or S-hook.

2.14 FIXTURE SUPPORTS

A. General: Fixture and equipment supports shall be compatible with plumbing fixture and equipment and chase width. Willoughby, Manufacturer: Zurn, Josam, Wade, Smith or Mifab.

B. Wall-Hung Closet Carriers: Carrier shall be cast iron with adjustable closet connection, adjustable pylon support feet, ABS extension with test cap as required, bowl stabilizer, chrome plated trim, coated accessories and neoprene fixture gasket. Carrier shall be suitable for use with siphon jet water closets.
   1. Closets shall meet or exceed the strength and deflection requirements of ANSI A112.6.1M-1997, "Supports for Off-the-Floor Plumbing Fixtures for Public Use."
   2. Where fixtures are indicated for use by the handicapped, provide carrier assembly with suitable adjustability as required for mounting fixture at proper height.
   3. Single closet carriers shall be provided with anchor foot leveling device bolted to floor for a positive securing of fixture.

C. Wall-Hung Urinal Supports: High-strength steel uprights with block bases for bolting to floor.

D. Electric Water Cooler Wall Supports: Floor-mounted fixture support, adjustable, heavy-duty steel plate and supporting studs. High-strength steel uprights shall have feet for bolting to floor.

E. Lavatory Supports: Floor-mounted support, concealed uprights, coated concealed arms with fixture locking device.

2.15 EXPANSION JOINTS

A. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.
   1. Manufacturers:
      a. Badger Industries.
      b. Flex-Hose Co., Inc.
      c. Flexicraft Industries.
      d. Hyspan Precision Products, Inc.
      e. Metraflex, Inc.
2. Metal-Bellows Expansion Joints for Copper Piping: Multiple-ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.

3. Minimum Pressure Rating: 150 psig, unless otherwise indicated.

B. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Available Manufacturers:
   a. Flex-Hose Co., Inc.
   b. Flexicraft Industries.
   c. Metraflex, Inc.

2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder-joint end connections.
   a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

2.16 MATERIALS FOR ANCHORS

A. Steel Shapes and Plates: ASTM A 36/A 36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

2. Expansion Plug: Zinc-coated steel.

E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2.17 STEEL PIPE HANGERS AND EQUIPMENT SUPPORTS

A. Description: MSS SP-58-2009; “Pipe Hangers and support-- Materials, Design, Manufacture, Selection, Application and Installation”: Types 1 through 59, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

1. Manufacturers:
   a. Anvil.
   b. B-Line Systems, Inc.
   c. ERICO/Michigan Hanger Co.
   d. Hubbard Enterprises/HOLDRITE®
   e. PHD Manufacturing, Inc.

B. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.18 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts. For piping 2” and below, manufactured specialty products formed from pre-galvanized commercial steel.

1. The total weight of piping and components upon each trapeze span shall not exceed the manufacturers load rating. Load ratings must include a minimum 2 X safety factor.

2.19 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

1. Manufacturers:
   b. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   c. Hubbard Enterprises/HOLDRITE®
   d. PHD Manufacturing, Inc.
   e. Unistrut Corp.; Tyco International, Ltd.

B. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

C. Nonmetallic Coatings: Plastic coating, jacket, or liner.
2.20 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

1. Manufacturers:
   a. Carpenter & Paterson, Inc.
   b. ERICO/Michigan Hanger Co.
   c. Pipe Shields, Inc.

B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.21 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated or stainless steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Manufacturers:
   a. Hilti, Inc.
   b. Hubbard Enterprises/HOLDRITE®
   c. ITW Ramset/Red Head.
   d. Powers Fasteners.

2.22 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

1. Manufacturers:
   b. HOLDRITE Corp.; Hubbard Enterprises.
   c. Samco Stamping, Inc.
2.23 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.24 MOTORS

A. GENERAL MOTOR REQUIREMENTS

1. Comply with NEMA MG 1 unless otherwise indicated.
2. Comply with IEEE 841 for severe-duty motors.

B. MOTOR CHARACTERISTICS

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. POLYPHASE MOTORS

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
   a. For motors with 2:1 speed ratio, consequent pole, single winding.
   b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.

D. SINGLE-PHASE MOTORS

1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
   a. Permanent-split capacitor.
   b. Split phase.
   c. Capacitor start, inductor run.
   d. Capacitor start, capacitor run.
3. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.


5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.25 SEISMIC CONTROLS

A. General: Provide complete seismic restraint systems for all plumbing piping and equipment. Seismic restraint systems for plumbing work shall be provided under this Division 22, and shall be engineered, furnished and installed to meet the same requirements specified for HVAC vibration isolation systems in Section 230540 “Vibration and Seismic Controls for HVAC.” The Contractor shall provide the services of a Qualified Professional Engineer (QPE), typically a structural engineer, to engineer the seismic controls as outlined in Section 230540 “Vibration and Seismic Controls for HVAC.” Note that certain seismic restraint manufacturers provide QPE services.

B. Seismic Restraints for New Construction: Provide engineering for seismic control of all new and relocated equipment and piping specified in Division 22. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards.

C. Components with Importance Factor Ip=1.5: Engineering, selection and placement of seismic restraints shall be based on the following components having an Importance Factor of Ip=1.5:

1. All sizes of piping located in Electrical Rooms, Mechanical Rooms, Generator Rooms and Refrigeration Rooms. This applies to all kinds of piping, whether connected to equipment in those rooms or not.

2. Domestic cold-water equipment and piping greater than two inches in size. Domestic cold-water piping two inches in size and less that does not have a readily-accessible isolation valve separating it from any piping greater than two inches in size.

3. Domestic hot water (including hot water recirculation) equipment and piping greater than two inches in size. Domestic hot water (including hot water recirculation) piping two inches in size and less that does not have a readily-accessible isolation valve separating it from any piping greater than two inches in size.

4. Waste and Vent piping greater than two inches in size.

5. Roof and similar rainwater drainage piping greater than two inches in size.

6. All other components required by Code to have an importance factor of Ip=1.5.

D. Components with Importance Factor Ip=1.0: All components not identified above as having an Importance Factor of Ip=1.5.

E. Omission of restraints for small components: Restraints may be omitted for smaller equipment and piping only where specifically allowed by Code and referenced Standards, and where specifically allowed by the Qualified Professional Engineer (QPE). Restraints may only be omitted after the QPE has determined that adequate flexibility will be provided between restrained and non-restrained connected elements and determined that movement of unrestrained elements will not cause damage to adjacent elements.
2.26 INSULATION SYSTEMS

A. Insulation for plumbing piping, valves and equipment shall be furnished and installed to meet the requirements specified for Insulation Systems in Section 220700 “Plumbing Insulation.”

B. New Work: Completely insulate all new work as specified and scheduled.

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

D. 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.

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

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

G. Thermal Requirements for all Pipe Insulation: Insulation thickness and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

H. Glass Fiber Preformed Pipe Insulation: Glass fiber meeting ASTM C547, rigid molded. "K" value 0.23 at 75°F. Maximum service temperature shall not exceed 850°F. Jacket shall be high density, white Kraft bonded to aluminum foil for vapor barrier, reinforced with fiberglass yarn, permanently treated, secured with self-sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples coated with vapor barrier mastic.

   1. Manufacturers:
      b. Knauf Insulation "1000 Pipe Insulation."
      c. Owens-Corning ASJ/SSLII.

2.27 FIXTURE AND EQUIPMENT SUPPORTS

A. General: Fixture and equipment supports shall be compatible with plumbing fixture and equipment and chase width.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. 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.
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 to permit valve servicing.

G. Install piping at indicated and/or code-required slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors where exposed to view from any location in a finished space and in stairways.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
   1. Cut sleeves to length for mounting flush with both surfaces. Exception: Extend sleeves installed in floors of mechanical equipment areas or other potentially-wet areas two inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
   2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
      a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
      b. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two inches above finished floor level.
   3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

N. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for one-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping one to two-inch in size, adjacent to each valve unless valve construction facilitates disassembly 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. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in wet piping systems.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 INSTALLATION OF PLUMBING FIXTURE AND EQUIPMENT CARRIER SUPPORTS

A. General: All fixtures shall be rigidly installed. Carriers shall have adjustable block base feet to permit vertical position of uprights regardless of uneven floor surface. Each carrier base shall be securely bolted to floor. Where 25-gauge steel framing is used for wallboard finish, provide additional structural bracing to ensure rigid installation of fixtures.

B. Wall-Hung Closet Supports: Carriers for closets; vertical or horizontal support and drainage fitting with foot and cast-iron closet coupling, both of proper length for the wall thickness. Provide hanger rod support feet at each corner. Install in accordance with manufacturer’s recommendations. Carrier feet shall be bolted to the floor. Carrier connection to fixture shall be made with manufacturer’s standard neoprene seal.

C. Wall Hung Urinal Supports: Supports shall be installed according to manufacturer’s instructions. Where steel uprights are used, block bases shall be securely bolted to floor structure.

D. Electric Water Cooler Wall Supports: Supports shall be installed according to manufacturer’s instructions. Where steel uprights are used, block bases shall be securely bolted to floor structure.

E. Wall-Hung Lavatory Supports: For floor mounted concealed arm type with floor supports, bolt feet to floor structure. For wall-mounted type, provide heavy-duty steel plate welded or bolted to vertical steel studs. Support types shall be compatible with fixture manufacturer and wall thickness.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05, Section 055000 "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.7 THERMOMETER APPLICATIONS

A. Install thermometers in the outlet of each hot-water heater or storage tank.

3.8 GAGE APPLICATIONS

A. Install pressure gages at the inlet and discharge of each pressure-reducing valve.
B. Install pressure gages at suction and discharge of each pump.

3.9 THERMOMETER AND GAGE INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install needle-valve and snubber fitting in piping for each pressure gage.

E. Install test plugs in tees in piping.

F. Install connection fittings for attachment to portable indicators in accessible locations.

G. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

H. Adjust faces of thermometers and gages to proper angle for best visibility.

3.10 HEAT TRACING

A. General

1. Furnish and Install a complete UL Listed, CSA Certified, or FM Approved system of heating cables, components, and controls to (choose one: prevent pipes from freezing, provide freeze protection of sprinkler system piping, provide flow maintenance of grease lines, provide flow maintenance for fuel oil).

B. Materials

1. The self-regulating heating cable shall consist of two (2) 16 AWG nickel-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heating cable to be cut to length in the field. The heating cable shall be covered by a radiation-crosslinked, modified polyolefin dielectric jacket. To provide a ground path and to enhance the heating cable’s ruggedness, the heating cable shall have a braid of tinned copper and an outer jacket of (select: modified polyolefin (-CR) or fluoropolymer (-CT)), as required per section 427-23 of the NEC-1996. For installation on plastic piping, the heating cable shall be applied using aluminum tape (AT-180).

2. In order to conserve energy and to prevent overheating, the heating cable shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heating cable output going from 40°F pipe temperature operation to 150°F pipe temperature operation.

3. The heating cable shall operate on line voltages of (select: 120, 208, 220, 240, or 277) volts without the use of transformers.
4. The heating cable for metal-pipe freeze protection shall be sized according to the table below. The required heating cable output rating is in watts per foot at 50°F. (Heating cable selection based on 1-inch fiberglass insulation on metal piping.)

<table>
<thead>
<tr>
<th>Pipe size (inches)</th>
<th>0°F</th>
<th>−20°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 or less</td>
<td>5 watts</td>
<td>5 watts</td>
</tr>
<tr>
<td>4</td>
<td>5 watts</td>
<td>8 watts</td>
</tr>
<tr>
<td>6</td>
<td>8 watts</td>
<td>8 watts</td>
</tr>
<tr>
<td>8</td>
<td>8 watts</td>
<td>2 strips–5 watts</td>
</tr>
<tr>
<td>10</td>
<td>2 strips–5 watts</td>
<td>2 strips–8 watts</td>
</tr>
</tbody>
</table>

5. The heating cable shall be XL-Trace cable as manufactured by Raychem Corporation or equal.
6. Power connection, end seal, splice, and tee kit components shall be applied in the field.
7. Heating cable circuit shall be protected by a ground-fault device for equipment protection. This requirement is in accordance with section 427-22 of the NEC-1996.

C. Components

1. All heating-cable components shall be UL Listed, CSA Certified, or FM Approved for use as part of the system to provide (choose one: pipe freeze protection, flow maintenance). Component enclosures shall be rated NEMA 4X to prevent water ingress and corrosion. Installation shall not require the installing contractor to cut into the heating-cable core to expose the bus wires. Connection systems that require the installing contractor to strip the bus wires or that use crimps or terminal blocks, shall not be acceptable. All components that make an electrical connection shall be reenterable for servicing. No component shall use silicone to seal the electrical connections. An exception will be made in areas where a conduit transition is required.

D. System Control

1. Option 1: Manual Control
   a. The system shall be controlled by a switch, either directly or through an appropriate contactor.

2. Option 2: Thermostatic Control–Ambient Sensing
   a. The system shall be controlled by an ambient sensing thermostat (choose: AMC-1A or AMC-F5) set at 40°F either directly or through an appropriate contactor.

3. Option 3: Thermostatic Control–Line Sensing
   a. The system shall be controlled by a line sensing thermostat (choose: AMC-F5 fixed at 40°F or AMC-1B variable set point) set at 40°F either directly or through an appropriate contactor.

E. Execution

1. Installation:
a. A. System must be installed per manufacturer’s recommendations.
b. B. Apply the heating cable linearly on the pipe after piping has been successfully pressure-tested.
c. Secure the heating cable to piping with cable ties or fiberglass tape.
d. C. Apply “Electric Traced” labels to the outside of the thermal insulation.

2. Tests:
   a. After installation and before and after installing the thermal insulation, subject heating cable to testing using a
   b. 2500-Vdc Megger, Minimum insulation resistance shall be 20 megohms or greater.

3.11 HEAT TRACE INSTALLATION

A. Electric Heating Cable Installation for Freeze Protection for Piping:
   1. Install self-regulating heat -trace.
   2. Install electric heating cables after piping has been tested and before insulation is installed.
   3. Install electric heating cables according to IEEE 515.1.
   4. Install insulation over piping with electric cables according to Section "Plumbing Insulation."
   5. Install warning tape on piping insulation where piping is equipped with electric heating cables.

B. Set field-adjustable switches and circuit-breaker trip ranges.

C. Protect installed heating cables, including nonheating leads, from damage.

D. Connections:
   1. Ground equipment according to Section "Grounding and Bonding for Electrical Systems."
   2. Connect wiring according to Section "Low-Voltage Electrical Power Conductors and Cables."

3.12 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

3.13 EXPANSION-JOINT INSTALLATION

A. Install manufactured, nonmetallic expansion joints according to FSA’s "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

B. Install expansion joints of sizes matching size of piping in which they are installed.
C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.14 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.
   2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.15 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

3.16 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.17 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Section "Plumbing Fixtures" for plumbing fixtures.

F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.


H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Install lateral bracing with pipe hangers and supports to prevent swaying.

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping.

K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2 12 inches long and 0.048 inch thick.

5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.18 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

C. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

D. Use padded hangers for piping that is subject to scratching.

3.19 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:
   1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Section "Roof Accessories" for curbs.

I. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Section "Plumbing Fixtures" for plumbing fixtures.

J. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.


L. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

M. Install lateral bracing with pipe hangers and supports to prevent swaying.

N. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

O. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

P. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

Q. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Use thermal-hanger shield insert with clamp sized to match OD of insert.
b. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2 12 inches long and 0.048 inch thick.

5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.20 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.21 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
   1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
   2. Obtain fusion without undercut or overlap.
   3. Remove welding flux immediately.
   4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.
3.22 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.23 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 220500
SECTION 220700 - PLUMBING INSULATION 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. Insulation Materials:
   a. Calcium silicate.
   b. Flexible elastomeric.
   c. Glass fiber/mineral fiber.
   d. Polyisocyanurate.

2. Insulating cements.
3. Adhesives.
5. Lagging adhesives.
7. Factory-applied jackets.
10. Field-applied jackets.
11. Tapes.
12. Securements.
13. Corner Angles.

B. Related Sections include the following:

1. Section "HVAC Insulation."

1.3 SUBMITTALS

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

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. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency. Insulation shall have a flame spread index of 25 or less and smoke developed rating index of 50 or less.

C. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1

1.5 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.

1.6 COORDINATION

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

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. 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 before installation of insulation.

1.7 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
A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

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.

2.2 PIPE INSULATION

A. Thermal Requirements for all Pipe Insulation: Insulation thickness and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

B. Glass Fiber Preformed Pipe Insulation: Glass fiber meeting ASTM C547, rigid molded. "K" value 0.23 at 75°F. Maximum service temperature shall not exceed 850°F. Jacket shall be high density, white Kraft bonded to aluminum foil for vapor barrier, reinforced with fiberglass yarn, permanently treated, secured with self-sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples coated with vapor barrier mastic.

1. Manufacturer: Johns Manville "Micro-Lok AP-T Plus," Owens-Corning ASJ/SSLII or Knauf Insulation "1000 Pipe Insulation".

2.3 FIELD APPLIED JACKETS

A. Jacketing of Pipes Exposed to Weather: All piping exposed to weather shall be finished with an aluminum jacket over the insulation. Aluminum jacket material shall be embossed or corrugated sheet, 0.016" nominal thickness, conforming to ASTM B209, temper H-14. Jacketing shall be applied with joints lapped not less than 2" and shall be secured with 3/8" x 0.020" thick aluminum bands located at each circumferential lap and at not more than 9" intervals throughout. Horizontal joints shall lap downward to shed water. Vertical joints shall be sealed with weatherproof silicone sealant.

1. Manufacturer: Childers Products, Division of ITW "Metal Jacketing Systems", Pabco Metals Corporation, "Surefit" or RPR Products Inc, "Insul-Mate".

B. PVC Plastic: One-piece molded type fitting covers and jacketing material, gloss white. Connections, tacks, pressure sensitive color matching vinyl tape. PVC material shall be 25 flame spread and 50 smoke development rated per ASTM E-84.

1. Manufacturer: Knauf Fiber Glass "Proto Fitting Cover System" or Johns Manville "Zeston 2000 PVC" or Speedline Corporation "SmokeSafe".

1. Manufacturer: Dow Chemical Company Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

D. Butt Straps: Materials shall be identical in all respects and appearance to the basic jacket material.

2.4 INSULATING CEMENTS


B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement 100 to 1200 deg: Comply with ASTM C 449/C 449M.


2.5 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. Mineral-Fiber or Fiber Glass Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.


D. PVC Jacket Adhesive: Compatible with PVC jacket.


2.6 MASTICS
A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.

B. Vapor-Barrier Mastic (Water-Based): Suitable for indoor and outdoor use on below ambient services. Water-vapor permeance to ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness. Minus 20 to plus 180 deg F service temperature range.


2.7 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation. Minus 50 to plus 180 deg F service temperature range.


2.8 SEALANTS

A. FSK and Metal Jacket Flashing Sealants: Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 250 deg F service temperature range. Color shall be aluminum.

1. Manufacturer: Childers Products, Division of ITW; "CP-76-8", Childers Products, Division of ITW; "CP-76-8", Foster Products Corporation, H. B. Fuller Company; "95-44", Foster Products Corporation, H. B. Fuller Company; "405", Mon-Eco Industries, Inc.; "44-05" or Vimasco Corporation "750”.

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants. Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 250 deg F service temperature range. Color shall be white.

1. Manufacturer: Childers Products, Division of ITW "CP-76”.

2.9 TAPES

A. ASJ Tape: White, 3-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Manufacturer: Avery Dennison Corporation, Specialty Tapes Division "Fasson 0835", Compac Corp. "104 and 105", Ideal Tape Co., Inc., an American Biltrite Company;
"428 AWF ASJ", Venture Tape; "1540 CW Plus, 1542 CW Plus", and "1542 CW Plus/SQ".

B. FSK Tape: Foil-face, 3-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
   1. Manufacturer: Avery Dennison Corporation, Specialty Tapes Division "Fasson 0827," Compac Corp. "110 and 111", Ideal Tape Co., Inc., an American Biltrite Company "491 AWF FSK" or Venture Tape "1525 CW, 1528 CW, and 1528 CW/SQ".

C. PVC Tape: White, 2-inch wide, vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   1. Manufacturer: Avery Dennison Corporation, Specialty Tapes Division "Fasson 0555", Compac Corp. "130", Ideal Tape Co., Inc., an American Biltrite Company "370 White PVC" tape or Venture Tape "1506 CW NS".

D. PVDC Tape for Indoor Applications: White, 3-inch wide, vapor-retarder PVDC tape with acrylic adhesive.
   1. Manufacturer: Dow Chemical Company "Saran 540 Vapor Retarder Tape".

E. PVDC Tape for Outdoor Applications: White, 3-inch wide, vapor-retarder PVDC tape with acrylic adhesive.
   1. Manufacturer: Dow Chemical Company "Saran 560 Vapor Retarder Tape".

2.10 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
      a. Childers Products; Bands.
      b. PABCO Metals Corporation; Bands.
      c. RPR Products, Inc.; Bands.
   2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch (0.38 mm) thick, 3/4-inch wide.

B. Insulation Pins and Hangers:
   1. 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.
      a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins:
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.

3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
   a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.
      2) GEMCO; Press and Peel.
      3) Midwest Fasteners, Inc.; Self Stick.
6. **Insulation-Retaining Washers:** Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   1) AGM Industries, Inc.; RC-150.
   2) GEMCO; R-150.
   3) Midwest Fasteners, Inc.; WA-150.
   4) Nelson Stud Welding; Speed Clips.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. **Nonmetal Insulation-Retaining Washers:** Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

   a. **Products:** Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

   1) GEMCO.
   2) Midwest Fasteners, Inc.

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

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2.11 **CORNER ANGLES**

A. **PVC Corner Angles:** 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. **Aluminum Corner Angles:** 0.040-inch-thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

C. **Stainless-Steel Corner Angles:** 0.024-inch-thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or 316.

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**PART 3 - EXECUTION**

3.1 **EXAMINATION**

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. 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.

B. Surface Preparation: 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 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 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 trade 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.

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

G. Keep insulation materials dry during application and finishing.

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 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.
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.
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 2 inches o.c. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape as recommended by insulation material manufacturer 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 more than 75 percent of its nominal thickness.

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 (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar 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.
5. Handholes.
6. Cleanouts.
3.4 INSULATION WORK IN GENERAL

A. General: Except as specified, material shall be installed in accordance with the recommendations of the manufacturer.

1. Do not apply insulation until pipe surfaces to be covered have been leak tested, have had rust and scale removed, and have been cleaned, dried and inspected.
2. Insulation shall be kept dry and clean at all times.
3. Continue insulation vapor barrier through penetrations except where prohibited by code.
4. Continue pipe insulation through gypsum and masonry walls only if fire stopping specified in Division 7 has a UL Listed assembly that includes a jacketed insulation. Coordinate with General Contractor.
5. All work shall be performed at ambient and equivalent temperatures as recommended by the manufacturers.
6. Joints shall be staggered on multi-layer insulation.
7. Do not apply insulation until heat tracing specified elsewhere in other sections of this Specification is completed and tested.
8. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces.

3.5 INSULATION INSTALLATION, PIPING

A. General: Pipe insulation shall be installed in strict conformance to the manufacturer’s recommendations. Pipe insulation shall be continuous and installed on all fittings and appurtenances unless specified otherwise. Installation shall be with full-length units of insulation and using a single-cut piece to complete a run. Provide jackets for all pipe insulation.

B. Flexible Elastomeric Insulation: Insulation shall be tubular form. Sweat fittings shall be insulated with miter-cut pieces the same size as on adjacent piping. Screwed fittings shall be insulated with sleeved fitting covers fabricated from miter-cut pieces and shall be overlapped and sealed to the adjacent pipe insulation using an adhesive compatible with the material.

1. Flexible elastomeric insulation shall not be used on surfaces greater than 180°F. Insulation exposed to weather and not shown to have jacketing shall be protected with two coats of UV-resistant finish as recommended by the manufacturer after the adhesive is dry.

C. Unions, Flanges, Strainers, and Valves:

1. Screwed and Welding Fitting and Screwed Pattern Valves: On exposed work, insulate to a diameter equal to insulation of adjacent piping; on concealed work, same insulation thickness as on adjacent piping; in all cases, same material as specified for adjacent piping; fitting covers to be as specified hereinafter.
2. Flanges and Flanged Valves: Insulate on all steam piping. Use lags of same material as pipe insulation, overlapping adjacent covering, filled up to uniform outer surface with insulating cement and fitting covers specified hereinafter.

D. Thermometer and Test Wells: Insulate test thermometer, industrial thermometer, and other test wells over their exterior length. Insulate thermometer wells protruding above finish pipe or
equipment insulation. Neatly taper insulation away from top of well. Insulation on thermometer wells shall be 1-1/2" minimum thickness.

E. Insulation Support at Hangers:

1. Provide support shield and 360 degree insert between support shield and piping on piping 1-1/2" diameter and larger. Fabricate hydrous calcium silicate or other heavy density insulating material suitable for the temperature. Shield shall be fabricated of 14-gauge galvanized sheet metal. Insulation shields and inserts shall be not less than the following lengths:

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Shield Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2” to 2-1/2”</td>
<td>10”</td>
</tr>
<tr>
<td>3” to 6”</td>
<td>12”</td>
</tr>
<tr>
<td>8” to 10”</td>
<td>16”</td>
</tr>
</tbody>
</table>

2. Vapor-barrier facing of the insert shall be of the same material as the facing on the adjacent insulation. Seal inserts into the insulation with lagging adhesive for vapor seal. Where anchors are secured to insulated chilled piping, insulate anchors same as piping for a distance not less than four times insulation thickness to prevent condensation.

F. Sleeves and Wall Chases: Insulation on pipes through walls and floors shall be full size and jacketed same as adjacent insulation. Provide a metal jacket over the insulation on pipe passing through sleeves in non-fire rated walls where caulking is required.

1. Where penetrating interior walls, extend the metal jacket 2 inches out on either side of the wall and secure on each end with a band.
2. Provide adequate support on vertical pipe to prevent slipping.

G. Allowances for Expansion: At points where pipe will move during expansion and contraction (expansion joints, Z-bends, expansion loops, and ells), clearances between the pipe and encased insulation shall be sized to permit full pipe movement without cracking or damaging insulation and casing or jacket.

H. Insulation at Mechanical Pipe Couplings: PVC insulated fitting covers shall be applied after the installation is installed. Installation shall comply with the manufacturer's recommended procedures. Connection with the pipe insulation shall be done in a neat, finished appearance, and any required vapor barrier shall be maintained.

I. Insulation at Roof Drains and Overflow Drains: Cover body of roof drains with heavy coating of insulating mastic or plastic insulating cement. Finish with canvas or glass cloth covering.

J. Rainwater Drainage Piping: Insulate all piping in the heated portions of the building.

K. Rainwater Drainage Overflow Piping: Insulate all piping within 10 feet of the points this piping enters and leaves the heated portion of the building.

L. Plumbing Vent Piping: Insulate all piping within 10 feet of the points this piping enters the heated portion of the building.
3.6 PIPING MINIMUM INSULATION SCHEDULE

A. General: Pipe insulation shall be provided for all piping systems listed below. The operating temperatures listed for the following piping systems shall be the basis upon which the insulation thickness requirements apply.

- Interior domestic cold water: below 60°F.
- Interior irrigation water: below 60°F.
- Domestic hot water and recirculating piping: 180°F.
- Cooling coil condensate drain: Below 60°F.
- Downspout or rainleader piping: Below 60°F.

B. Thickness: Thickness of pipe insulation for each application shall be in accordance with the following table:

<table>
<thead>
<tr>
<th>System</th>
<th>Operating Temp. (°F)</th>
<th>Material</th>
<th>Nominal Pipe Size**</th>
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<td>and plumbing vents</td>
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3.7 SPECIAL PIPE INSULATION REQUIREMENTS:

A. Cold Piping Insulation: Exposed ends of fiberglass insulation shall be sealed with a vapor retarder mastic installed per the manufacturer’s recommendations. Vapor seals at butt joints shall be applied at every fourth pipe section and at each fitting to isolate any water incursion.

B. Removable Insulation Covers: Install removable insulation covers at the following locations: Flanged hot water, steam and valves. 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 adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
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.

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: Install insulation continuously through penetrations of fire-rated walls and partitions.

3.8 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.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.

5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.

6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
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.

9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

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 adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

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 (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

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

3.9 GLASS FIBER/MINERAL-FIBER INSULATION INSTALLATION

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 factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed 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 mineral-fiber 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 preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered 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.

3.10 FIELD-APPLIED JACKET INSTALLATION

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; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. 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.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-pre-sized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install pre-sized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch circumference limit allows for 2-inch overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

END OF SECTION 220700
SECTION 221100 - WATER DISTRIBUTION 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. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Encasement for piping.
   3. Ball valves.
   5. Gate valves.
   6. Check valves.
   7. Strainers.
   8. Mechanically coupled piping systems.
   11. Flexible connectors.
   13. Trap primers.
   15. Wall Hydrants.

B. Related Sections:
   1. Section 220500 "Common Work for Plumbing."

1.3 PERFORMANCE REQUIREMENTS

1. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to SEI/ASCE 7.

1.4 SUBMITTALS

A. Product Data: For the following products:
   1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
   2. Encasement for piping.
3. Ball valves.
5. Gate valves.
6. Check valves.
7. Strainers.
8. Mechanically coupled piping systems.
11. Flexible connectors.
13. Trap primers.
15. Wall Hydrants.

1.5 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
B. Comply with NSF 61 for potable domestic water piping and components.
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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Domestic water pumps:
   1. Retain shipping flange protective covers and protective coatings during storage.
   2. Protect bearings and couplings against damage.
   3. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 WATER PIPE AND FITTINGS (POTABLE AND NON-POTABLE WATER)

A. Pipe General:

B. Fittings for Copper Tubing:
   1. Wrought copper or bronze solder-joint pressure fittings conforming to ANSI/ASME B16.18 and ANSI/ASME B16.22.
2. Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment.

3. Solder: Lead-free, silver bearing, NSF approved, for all joints in copper water tubing. Apply flux carefully and remove all excess.

4. Press Fittings: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.

C. Unions, Copper Piping: 125-lb. wrought copper or cast bronze, solder joint type; ANSI/ASME B16.22 or ANSI/ASME B16.18.

D. Dielectric Fittings: See Section 220500 “Common Work for Plumbing.”

2.2 VALVES

A. General: Provide valves on all water piping systems, 125-psi system working pressure and below, where shown or specified. Provide valve in water or drain connection to each removable or replaceable item of equipment.

B. Shut-Off Valves 2" and Smaller: Ball type, bronze, lead free. Bronze shall be ASTM B584 Alloy C84400. Two-piece body style, threaded ends, full port, chrome plated solid brass ball, teflon seats, adjustable packing, lever handle, blowout proof stem, 150 wsp, 600 wog.

1. Approved Manufacturers:
   a. Apollo No. 77CLF.
   b. Crane Co. Model LF 9201.
   c. Hammond Valve UP8301A.
   d. Jomar International, LTD. JF-100T.
   e. Milwaukee BA-400.
   g. Red & White Valve Corp. 5044F.
   h. Watts No. B-6080.

C. Shut-Off Valves 2-1/2" and Larger: Butterfly type, full lug, ductile iron body, 400 series stainless steel stem, aluminum bronze disc, EPDM liner and seals, upper and lower stem bearing, blowout proof stem, extended neck for minimum 2" insulation, manufacturer recommended for bi-directional dead-end service at full rated pressure without a downstream flange, sizes 2-1/2" through 4" shall be lever operated and 200 psi cwp.

1. Approved Manufacturers:
   a. Demco No. NEC-511.

D. Gate Valves 2-1/2" and Larger: Cast-iron body, bronze trim, OS & Y, bolted bonnet, flanged ends, 125 wsp, 200 wog.

1. Approved Manufacturers:
a. Milwaukee No. F2885-A.
b. Nibco No. F-617-0.

E. Swing Check Valves 2" and Smaller: Bronze body, threaded ends, swing check, Teflon disc and seat, 125 wsp, 200 wog.

1. Approved Manufacturers:
   a. Milwaukee No. 509-T.
   b. Nibco No. T-413-Y.
   c. Stockham No. B-320-T.

F. Swing Check Valves 2-1/2" and Larger: Cast iron body, horizontal swing check, bronze trim, with brass-faced disc, brass body seat ring, flanged pattern, 125 wsp, 200 wog.

1. Approved Manufacturers:
   a. Milwaukee No. F2974-A.
   b. Nibco No. F-918-B.

G. Check Valves, Nonslam Type 2-1/2" and Larger: Wafer style, cast-iron body, bronze disc and seat, center guided, stainless steel spring and screws, 200 non-shock wog.

1. Approved Manufacturers:
   a. Metraflex Style 700.
   b. Milwaukee No. 1400.
   c. Nibco No. F-910-B.

H. Check Valves in Copper Tubing: Bronze body and disc, soldered joint end connections, horizontal swing check, screwed cap, 125 wsp, 200 wog.

1. Approved Manufacturers:
   a. Milwaukee No. 1509.
   b. Nibco No. S-413-B.

I. Drain Valves 1/2" to 3/4" Sizes: Bronze ball valve, two-piece body, standard port, chrome plated brass ball, RPTFE seats, lever handle, blow out proof stem, threaded or soldered with hose end, cap and chain, 150 psi wsp, 600 psi wog.

1. Approved Manufacturers:
   a. Apollo 78/200 Series.
   b. Milwaukee No. BA-100H or BA-150H.
2.3 STRAINERS

A. Strainers: Strainers shall be Y-pattern with cast-iron or bronze bodies.

B. Domestic Water System Strainers 2" and Smaller: Threaded, 250 lb., wye-pattern. Monel or stainless-steel screen with 20 mesh perforations.
   1. Approved Manufacturers:
      a. Armstrong No. CA1SC-250.
      b. Conbraco 59 Series.
      c. Watts Series 77S.

C. Domestic Water System Strainers 2-1/2" and Larger: Flanged, 125 lb. Y-pattern, Monel or stainless-steel screens; 1/16 perforations for 2-1/2" to 5" size pipe; 1/8" perforations for 6" and larger pipe.
   1. Approved Manufacturers:
      b. Conbraco 539 Series.
      c. Watts Series 77F-D.

D. Strainers in Copper Tubing 2" and Smaller (Threaded Pattern): 200 lb., heavy-duty cast bronze body, Y-type, 20-mesh stainless steel screen, threaded blowdown end.
   1. Approved Manufacturers:
      a. Armstrong No. CA1SC-250.
      b. Conbraco 59 Series.
      c. Watts Series S777S.

E. Strainers in Copper Tubing 2" and Smaller (Solder Pattern): 200 lb., heavy-duty cast bronze body, Y-type, 20-mesh stainless steel screen, threaded blowdown end.
   1. Approved Manufacturers:
      a. Armstrong No. CA1SC-250.
      b. Conbraco 59-300 Series.
      c. Watts Series S777S.

2.4 MECHANICALLY COUPLED PIPING SYSTEMS

A. Systems: Mechanically coupled piping products are approved for use on the following systems only: Domestic Potable and Non-Potable Cold-Water Systems, 2” size and larger.

B. Mechanically grooved pipe couplings, fittings, valves and other grooved components may be used as an option to soldering, threading or flanged methods. All grooved components shall be of one manufacturer and shall conform to local codes and ordinances and ANSI/ASME B-31.1, B-31.9, UL/FM and IAPMO. The grooved end product manufacturer shall be ISO-9001 certified. Manufacturer: Victaulic Company, Tyco-Grinnell or Anvil International Gruvlok.
C. Pipe and Fittings:
   1. Copper tubing Type L, hard drawn, conforming to ASTM B88. The pipe shall be roll-grooved in accordance with the manufacturer's recommendations.
   2. Copper Piping Fittings: Fittings shall be constructed of copper, per ASTM B75, alloy C12200 or B152 alloy C11000 or bronze sand cast per ASTM B-584, copper alloy CDA 836.
   3. Fittings shall be grooved end fittings as designed in the manufacturer's catalog literature. Fittings shall be manufactured to copper tubing sizes, with grooves designed to accept grooved end couplings of the same manufacturer. Flaring of tube and fitting ends to IPS dimensions is not allowed.

D. Couplings and Components:
   1. Coupling housings shall be ductile iron conforming to ASTM A395 and A536; cast and ductile iron, and finished with copper alkyd enamel paint.
   2. Bolts and nuts shall be carbon steel track type conforming to ASTM A183, minimum tensile 110,000 psi.
   3. Gaskets in water piping system shall be Grade "E" EPDM, "FlushSeal®" style, with temperature range from -30°F to +230°F. (Gaskets UL classified in accordance with ANSI/NSF 61 for hot (+180°F) and cold (+80°F) potable water service.) Gasket selection for each system shall be in accordance with manufacturer's current recommendations to suit system pressure and temperature.
   4. Adapters shall be used at flanged connections, engaging directly into roll grooved copper tube and fittings and bolting directly to ANSI/ASME Class 125 and Class 150 flanged components, complete with standard flange bolts.

E. Dielectric Fittings: Dielectric fittings shall be used at piping connections between dissimilar metals and equipment to protect from local cell corrosion.
   1. Manufacturers:
      a. Anvil International Gruvlok "Di-Lok"
      b. Clearflow "Dielectric Waterway."
      c. Victaulic Corporation "Clearflow" Dielectric Waterway Style 47.

2.5 BACKFLOW PREVENTERS

A. Backflow preventers shall conform to the provisions of WAC 246-290-490, "Cross-Connection Control."

B. Reduced Pressure Backflow Preventers:
   1. Reduced pressure type, line pressure operated; state and local approved; low-pressure drop with accessories and fittings required for testing by water purveyor or authority having jurisdiction; gate valve on each side, supported on steel wall brackets.
   2. Manufacturer: Danfoss-Flomatic Model RPZ, Conbraco 40-200 Series, Zurn/Wilkins Model 375, Watts Series 909 or Febco Model 860.
   4. Operation: Continuous-pressure applications.
5. Pressure Loss: 12 psig maximum, through middle third of flow range.

6. Body: Bronze for NPS 2 and smaller; [cast iron with interior lining that complies with AWWA C550 or that is FDA approved] [steel with interior lining that complies with AWWA C550 or that is FDA approved] [stainless steel] for NPS 2-1/2 and larger.

7. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

8. Configuration: Designed for [horizontal, straight-through] [vertical-inlet, horizontal-center-section, and vertical-outlet] [vertical] flow.

9. Accessories:
   a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
   b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

C. Backflow-Preventer Test Kits:
   1. Approved Manufacturers:
      a. Conbraco Industries, Inc.
      b. FEBCO; a division of Watts Water Technologies, Inc.
      c. Flomatic Corporation.
      d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
      e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
   2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.6 PRESSURE REDUCING VALVES

A. Pressure Reducing Valves 2-1/2” and Smaller: Bronze body, 300 psi rated inlet high temperature rated diaphragm for hot or cold water, renewable stainless-steel seat, spring cage and orifice, threaded pattern, with Y-strainer and steel perforated strainer screen.

   1. Approved Manufacturers:
      a. Watts Series 223S or 223BS.
      b. Wilkins 500YSBR Series.

B. Accessory Connections: Install shut off valve on each side of reducing valve and full-sized bypass with shut off valve. Install strainer on inlet side of, and the same size as pressure reducing valve. Install pressure gauge on low pressure side of line.

2.7 THERMOSTATIC MIXING VALVES FOR EMERGENCY EYEWASH FIXTURE

A. Thermostatic Mixing Valve for Emergency Eyewash Fixture: The thermostatic mixing valve shall control outlet temperature over a wide range of flow and shall be designed specifically for eyewash applications. The valve shall include a dial thermometer to measure the temperature of tempered stream. Temperature adjustment shall be vandal resistant. The control mechanism shall employ a liquid-filled thermostatic motor to drive the valve without additional power.
requirements. The control mechanism shall employ a stainless-steel sliding piston control device with reverse seat closure and both fixed and variable cold-water bypass. In the event of interruption of the hot water supply, each control mechanism shall allow cold flow through both the fixed and variable by-pass. In the event of interruption of the cold-water supply, the control mechanism closes off the hot water port, stopping all flow. In the event the liquid motor fails, the control mechanism closed off the hot water port with the reverse seat and fully opens the internal variable bypass to allow cold water flow. Valve shall be bronze body. Valve assembly shall include lock set and mounting bracket. Inlet pressure shall not exceed 125 psi. Minimum supply pressure shall be 35 psi. Discharge temperature range shall be 70°F to 90°F. Set point shall be 85°F.

1. Approved Manufacturers:
   a. Lawler Model 911E.
   c. Powers "Hydroguard Series Emergency Tempering Valve".

2.8 FLEXIBLE CONNECTORS

A. Approved Manufacturers:

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex-Weld, Inc.
4. Hyspan Precision Products, Inc.
5. Metraflex, Inc.
6. Twin City Hose.

B. Bronze-Hose Flexible 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.

C. Stainless-Steel-Hose Flexible 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.

2.9 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:
   1. Approved Manufacturers:
      a. AMTROL, Inc.
      b. Josam Company.
      c. MIFAB, Inc.
d. Precision Plumbing Products, Inc.
e. Sioux Chief Manufacturing Company, Inc.
g. Tyler Pipe; Wade Div.
h. Watts Drainage Products.
i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.

3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.10 TRAP PRIMERS

A. Mechanical Trap Primers-Intermittent Water Flow Type, TPV-X: Adjustable-type automatic trap seal primer valve, cast bronze body, 1/2" copper sweat connections or union connections. Manufacturer: Josam 88250, Wade Fig. W2400, Smith Fig. 2699 or Mifab MI-TSP-2.

B. Drainage-Type, Trap-Seal Primer Device TPV-X: ASSE 1044, lavatory P-trap with 3/8 minimum trap makeup connection, 1-1/4 trap size minimum, chrome plated cast brass. Zurn Z1021-WL; Jay R. Smith 2698-CAN.

C. Vacuum Breaker Type, Trap-Seal Primer Device TPV-X: Flush valve type with 3/8 minimum trap makeup connection, water deflector, vacuum breaker, chrome plated cast brass. Sloan VBF-72-A2, Precision Plumbing Products FVP-1VP.

2.11 HOSE BIBBS

A. Hose Bibbs (HB-X):

1. Approved Manufacturers:
   b. Chicago 293-E27CP.
   c. MIFAB, Inc. MHY-90.
   e. Watts Drainage Products Model SC-8.
   g. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products. Model Z1341.

2. Standard: ASME A112.18.1 for sediment faucets.
5. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
10. Finish for Service Areas: Rough bronze, or chrome or nickel plated.
11. Finish for Finished Rooms: Chrome or nickel plated.
12. Operation for Equipment Rooms: Wheel handle or operating key.
13. Operation for Service Areas: Wheel handle or operating key.
15. Include operating key with each operating-key hose bibb.
16. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.12 WALL HYDRANTS

A. Wall Hydrants (HB-X):

1. Approved Manufacturers:
   b. Josam Company 71020.
   c. MIFAB, Inc. MHY-35.
   e. Watts Drainage Products Watts HY-330.
   f. Woodford Manufacturing Company; a division of WCM Industries, Inc. Model B74.
   g. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products. Model Z1330-C.

4. Operation: Loose key.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze [Chrome plated].
9. Operating Keys(s): One with each wall hydrant.

B. Nonfreeze Wall Hydrants (HB-X):

1. Approved Manufacturers:
   b. Josam Company 71000 Series.
   c. MIFAB, Inc. MHY-20.
   e. Watts Drainage Products Watts HY-725.
   g. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products. Model Z1320-C

4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
10. Operating Keys(s): One with each wall hydrant.

PART 3 - EXECUTION

3.1 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

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

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

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.

3.2 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 1” and larger and 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. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in wet piping systems.
3.3 Domestic Water Piping Installation

A. Special Requirements:

1. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.
2. Protect flanges, fittings, and piping specialties from moisture and dirt.

B. General Requirements:

1. Shutoff Valves: Install ball type shut-off valves at the base of each plumbing riser serving more than one fixture, in each branch line serving more than one fixture, and elsewhere as shown. Install valves in positions accessible for operation and repair.
2. Grading of Piping: Where possible, grade all lines to facilitate drainage. Provide drain valves at bottom of risers. All unnecessary traps in circulating lines shall be avoided. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.
3. Concealed Piping: Conceal all piping in finished areas of the building unless noted otherwise.
4. All piping shall be run parallel with building construction and 90° angles to same.
5. Provisions for Piping Covering: Allow sufficient space for the proper installation of the pipe covering. If piping is installed too close to other piping or equipment, the piping shall be moved to avoid such interferences.
6. Pipe in Shafts: Piping in vertical shafts which are accessible shall be arranged to prevent obstruction to the access openings.
7. Install no piping of any kind in electrical equipment rooms, telephone equipment rooms, or elevator machine rooms.
8. Unions: Install at connections to all equipment downstream of valves, at all equipment specialties, and wherever else required to permit easy connection and disconnection. Do not conceal unions in walls, partitions or inaccessible ceilings.
9. Where grooved piping systems are utilized, unions are not required. Couplings shall serve as unions.
10. Dielectric Fittings: Provide approved dielectric type waterways, fittings or flanges where pipe sections made of dissimilar metals are to be joined to prevent metal to metal contact. Do not use dielectric unions.

C. Connections to Fixtures:

1. General: Anchor supply connections at fixtures to steel straps secured to studs. At flush valves provide fitting with lugs secured to strap. At lavatories and other fixtures, secure piping directly to strap. Provide copper tubing stubs through wall for connection to compression type stops.
2. Contractor shall provide all necessary material and labor to connect to the plumbing system all fixtures and equipment having plumbing connections and which are furnished by the Owner or specified in other sections of these specifications.
3. The supply line to each item of equipment or fixture, except faucets, flush valves or other control valves which are supplied with an integral stop, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to all fixtures shall be anchored to prevent movement.
4. Partition-Type Stops: Provide on water supply to all fixtures which are not connected through individual exposed stops, integral stops, or stops in pipe space.


D. Water Hammer Arresters: Install on hot and cold-water piping, located close to each automatic faucet, control valve, flush valve, or any other type of quick closing valve or automatic valve, no exception. Sizing and placement shall conform to the requirements of PDI-WH201. Arresters shall be fully accessible.

E. Installation of Trap Primers: Install trap primers in strict compliance with the manufacturer's recommendations where readily accessible behind access doors or above accessible ceilings. Trap primer shall be located on domestic cold-water lines only. Do not prime shower drain traps.

F. Backflow Preventers:

1. Provide on service piping and other locations shown:

2. Install according to applicable requirements of WAC 248-54-285, "Cross-Connection Control".

3. Locate backflow preventers in same room as connected equipment or system.

4. Do not install bypass piping around backflow preventers.

5. Backflow preventers shall be installed so as to be fully accessible for testing and maintenance by the water purveyor.

6. Provide funnel below each backflow preventer discharge. Funnel shall include approved air gap and drain line to funnel floor drain or other approved receptor. Drain line shall be sized for maximum backflow preventer discharge. Provide steel wall brackets for support of backflow preventers.

G. Pressure Piping Regulations: All piping work, except drainage, shall conform to the "ANSI/ASME Building Services Piping Code," B31.9, including latest amendments.

H. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

I. Install balancing valves in locations where they can easily be adjusted.

J. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.

K. Install Y-pattern strainers for water on supply side of each control valve [water pressure-reducing valve] [solenoid valve] [and] [pump].

L. Install water-hammer arresters in water piping according to PDI-WH 201.

M. Install trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
3.4 MECHANICALLY COUPLED PIPING JOINTS

A. Rolled grooved pipe for mechanically coupled joints shall be installed in accordance with the manufacturer's specifications contained in the latest published literature.

B. Fabrication techniques for all mechanical joints in accordance with manufacturer's recommendations contained in the latest published literature.

3.5 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

   1. Reduced-pressure-principle backflow preventers.
   2. Double-check, backflow-prevention assemblies.
   5. Thermostatic, water mixing valves.
   6. Outlet boxes.
   7. Trap-seal primer valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220500 “Common Work for Plumbing.”

3.6 STERILIZATION OF DOMESTIC WATER PIPING


B. Sterilization and Flushing: All water piping, twenty-four (24) hour sterilization contact time, 50 parts per million chlorine concentration. Open all valves several times, following by flushing with clean water until residual chlorine is the same as that of potable water.

3.7 TESTING AND ADJUSTING

A. Water Piping: All domestic cold and hot water and non-potable water piping inside building shall be tested by hydrostatic pressure at 100 psi, for a minimum of 24 hours without any leaks. Provide a pressure gauge with a shutoff and bleeder valve at the highest point of the piping being tested. Only potable water shall be used for testing.

B. Set field-adjustable pressure set points of water pressure-reducing valves.

C. Set field-adjustable flow set points of balancing valves.

D. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.
3.8 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 221100
SECTION 221116 - DOMESTIC WATER 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. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Encasement for piping.
4. Flexible connectors.
5. Water meters furnished by utility company for installation by Contractor.
7. Escutcheons.
8. Sleeves and sleeve seals.
9. Wall penetration systems.

B. Related Section:

1. Division 22 Section "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to SEI/ASCE 7

1.4 SUBMITTALS

A. Product Data: For the following products:

1. Specialty valves.
2. Transition fittings.
3. Dielectric fittings.
4. Flexible connectors.
5. Water meters.
7. Escutcheons.
8. Sleeves and sleeve seals.
9. Water penetration systems.


C. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Fire-suppression-water piping.
2. Domestic water piping.
3. Compressed air piping.
4. HVAC hydronic piping.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

B. Comply with NSF 14 for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.

C. Comply with NSF 61 for potable domestic water piping and components.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Construction Manager no fewer than two days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Construction Manager's written permission.

1.7 COORDINATION

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

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 COPPER TUBE AND FITTINGS

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


4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

5. Copper Pressure-Seal-Joint Fittings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Elkhart Products Corporation; Industrial Division.
      2) NIBCO INC.
      3) Viega; Plumbing and Heating Systems.
   b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
   c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

6. Copper Push-on-Joint Fittings:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) NVent LLC.
   b. Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.

7. Copper-Tube Extruded-Tee Connections:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) T-DRILL Industries Inc.
   b. Description: Tee formed in copper tube according to ASTM F 2014.

8. Grooved-Joint Copper-Tube Appurtenances:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
2. Compact-Pattern, Mechanical-Joint Fittings: AWWA C153, ductile iron.

   a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.


2. Compact-Pattern, Push-on-Joint Fittings: AWWA C153, ductile iron.


C. Plain-End, Ductile-Iron Pipe: AWWA C151.
1. Grooved-Joint, Ductile-Iron-Pipe Appurtenances:
   a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1) Anvil International.
      2) Shurjoint Piping Products.
      3) Star Pipe Products.
      4) Victaulic Company.
   c. Grooved-End, Ductile-Iron-Pipe Couplings: AWWA C606 for ductile-iron-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B, Standard Weight. Include ends matching joining method.
   5. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:
      a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
         1) Anvil International.
         2) Shurjoint Piping Products.
         3) Star Pipe Products.
         4) Victaulic Company.
   b. Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 47/A 47M, malleable-iron casting; ASTM A 106/A 106M, steel pipe; or ASTM A 536, ductile-iron casting; with dimensions matching steel pipe.
   c. Grooved-End-Pipe Couplings for Galvanized-Steel Piping: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gaskets suitable for hot and cold water, and bolts and nuts.

2.5 CPVC PIPING

A. CPVC Pipe: ASTM F 441/F 441M, Schedule 40 and Schedule 80.
2. CPVC Threaded Fittings: ASTM F 437, Schedule 80.


2.6 PEX TUBE AND FITTINGS

A. PEX Distribution System: ASTM F 877, SDR 9 tubing.
   1. Fittings for PEX Tube: ASTM F 1807, metal-insert type with copper or stainless-steel crimp rings and matching PEX tube dimensions.
   2. Manifold: Multiple-outlet, plastic or corrosion-resistant-metal assembly complying with ASTM F 877; with plastic or corrosion-resistant-metal valve for each outlet.

2.7 PVC PIPE AND FITTINGS

A. PVC Pipe: ASTM D 1785, Schedule 40 and Schedule 80.
   2. PVC Schedule 80 Threaded Fittings: ASTM D 2464.

2.8 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8-inch-thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
E. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
F. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
G. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
2.9 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: Sheet or Tube.

C. Material: LLDPE film of 0.008-inch minimum thickness or high-density, cross-laminated PE film of 0.004-inch minimum thickness.

D. Color: Black or Natural.

2.10 SPECIALTY VALVES

A. Comply with requirements in Section 230523 "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

B. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

C. CPVC Union Ball Valves:

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

   a. American Valve, Inc.
   b. Asahi/America, Inc.
   c. Colonial Engineering, Inc.
   d. Fischer, George Inc.
   e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
   f. IPEX Inc.
   g. NIBCO INC.
   h. Sloane, George Fischer, Inc.
   i. Spears Manufacturing Company.
   j. Thermoplastic Valves Inc.

2. Description:

   b. Pressure Rating: 150 psig at 73 deg F.
   c. Body Material: CPVC.
   d. Body Design: Union type.
   e. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
   f. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded
   g. Ball: CPVC; full port.
   h. Seals: PTFE or EPDM-rubber O-rings.
   i. Handle: Tee shaped.

D. PVC Union Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Asahi/America, Inc.
   c. Colonial Engineering, Inc.
   d. Fischer, George Inc.
   e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
   f. IPEX Inc.
   g. Jomar International, LTD.
   h. King Bros. Industries.
   i. Legend Valve.
   k. NIBCO INC.
   l. Sloane, George Fischer, Inc.
   m. Spears Manufacturing Company.
   n. Thermoplastic Valves Inc.

2. Description:
   b. Pressure Rating: 150 psig at 73 deg F
   c. Body Material: PVC.
   d. Body Design: Union type.
   e. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
   f. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded.
   g. Ball: PVC; full port.
   h. Seals: PTFE or EPDM-rubber O-rings.
   i. Handle: Tee shaped.

E. CPVC Non-Union Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Asahi/America, Inc.
   c. King Bros. Industries.
   d. Legend Valve.
   e. NIBCO INC.
   f. Spears Manufacturing Company.
   g. Thermoplastic Valves Inc.

2. Description:
   b. Pressure Rating: 150 psig at 73 deg F
   c. Body Material: CPVC.
   d. Body Design: Non-union type.
   e. End Connections: Socket or threaded
   f. Ball: CPVC; full or reduced port.
g. Seals: PTFE or EPDM-rubber O-rings.
h. Handle: Tee shaped.

F. PVC Non-Union Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Asahi/America, Inc.
   c. Colonial Engineering, Inc.
   d. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
   e. IPEX Inc.
   f. Jomar International, LTD.
   g. King Bros. Industries.
   h. Legend Valve.
   i. McDonald, A.Y. Mfg. Co.
   j. NIBCO INC.
   k. Sloane, George Fischer, Inc.
   l. Spears Manufacturing Company.
   m. Thermoplastic Valves Inc.

2. Description:
   b. Pressure Rating: 150 psig at 73 deg F.
   c. Body Material: PVC.
   d. Body Design: Non-union type.
   e. End Connections: Socket or threaded.
   f. Ball: PVC; full or reduced port.
   g. Seals: PTFE or EPDM-rubber O-rings.
   h. Handle: Tee shaped.

G. CPVC Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Fischer, George Inc.
   b. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
   c. NIBCO INC.
   d. Sloane, George Fischer, Inc.
   e. Spears Manufacturing Company.
   f. Thermoplastic Valves Inc.

2. Description:
   a. Pressure Rating: 150 psig at 73 deg F.
   b. Body Material: CPVC.
   c. Body Design: Lug or wafer type.
   d. Seat: EPDM rubber.
e. Seals: PTFE or EPDM-rubber O-rings.
f. Disc: CPVC.
g. Stem: Stainless steel.
h. Handle: Lever.

H. PVC Butterfly Valves:

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

   a. American Valve, Inc.
   b. Asahi/America, Inc.
   c. Colonial Engineering, Inc.
   d. Fischer, George Inc.
   e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
   f. IPEX Inc.
   g. Legend Valve.
   h. NIBCO INC.
   i. Sloane, George Fischer, Inc.
   j. Spears Manufacturing Company.
   k. Thermoplastic Valves Inc.

2. Description:

   a. Pressure Rating: 150 psig at 73 deg F
   b. Body Material: PVC.
   c. Body Design: Lug or wafer type.
   d. Seat: EPDM rubber.
   e. Seals: PTFE or EPDM-rubber O-rings.
   f. Disc: PVC.
   g. Stem: Stainless steel.
   h. Handle: Lever.

I. CPVC Ball Check Valves:

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

   a. American Valve, Inc.
   b. Asahi/America, Inc.
   c. Colonial Engineering, Inc.
   d. Fischer, George Inc.
   e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
   f. IPEX Inc.
   g. NIBCO INC.
   h. Sloane, George Fischer, Inc.
   i. Spears Manufacturing Company.
   j. Thermoplastic Valves Inc.

2. Description:
a. Pressure Rating: 150 psig at 73 deg F
b. Body Material: CPVC.
c. Body Design: Union-type ball check.
d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
e. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded.
f. Ball: CPVC.
g. Seals: EPDM- or FKM-rubber O-rings.

J. PVC Ball Check Valves:

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

a. American Valve, Inc.
b. Asahi/America, Inc.
c. Colonial Engineering, Inc.
d. Fischer, George Inc.
e. Hayward Flow Control Systems; Hayward Industrial Products, Inc.
f. IPEX Inc.
g. Legend Valve.
h. NIBCO INC.
i. Sloane, George Fischer, Inc.
j. Spears Manufacturing Company.
k. Thermoplastic Valves Inc.

2. Description:

a. Pressure Rating: 150 psig at 73 deg F
b. Body Material: PVC.
c. Body Design: Union-type ball check.
d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
e. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded.
f. Ball: PVC.
g. Seals: EPDM- or FKM-rubber O-rings.

K. CPVC Gate Valves:

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

a. Sloane, George Fischer, Inc.
b. Spears Manufacturing Company.

2. Description:

a. Pressure Rating: 150 psig at 73 deg F
b. Body Material: CPVC.
c. Body Design: Nonrising stem.
d. End Connections for Valves NPS 2 and Smaller: socket or threaded.
e. End Connections for Valves NPS 2-1/2 to NPS 4: socket or threaded.
f. Gate and Stem: Plastic.
g. Seals: EPDM rubber.
h. Handle: Wheel.

L. PVC Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Asahi/America, Inc.
   b. King Bros. Industries.
   c. Sloane, George Fischer, Inc.
   d. Spears Manufacturing Company.

2. Description:
   a. Pressure Rating: 150 psig at 73 deg F
   b. Body Material: PVC.
   c. Body Design: Nonrising stem.
   d. End Connections for Valves NPS 2 and Smaller: socket or threaded.
   e. End Connections for Valves NPS 2-1/2 to NPS 4: socket or threaded.
   f. Gate and Stem: Plastic.
   g. Seals: EPDM rubber.
   h. Handle: Wheel.

2.11 TRANSITION FITTINGS

A. General Requirements:
   1. Same size as pipes to be joined.
   2. Pressure rating at least equal to pipes to be joined.
   3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Cascade Waterworks Manufacturing.
      b. Dresser, Inc.; Dresser Piping Specialties.
      c. Ford Meter Box Company, Inc. (The).
      d. JCM Industries.
      e. Romac Industries, Inc.
      f. Smith-Blair, Inc; a Sensus company.
      g. Viking Johnson; c/o Mueller Co.

D. Plastic-to-Metal Transition Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Harvel Plastics, Inc.
   c. Spears Manufacturing Company.

2. Description: CPVC or PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket[ or threaded] end.

E. Plastic-to-Metal Transition Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Colonial Engineering, Inc.
   b. NIBCO INC.
   c. Spears Manufacturing Company.

2. Description: CPVC or PVC four-part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

2.12 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Central Plastics Company.
   c. EPCO Sales, Inc.
   d. Hart Industries International, Inc.
   e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:
   a. Pressure Rating: 150 psig at 180 deg F.
   b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
b. Central Plastics Company.
c. EPCO Sales, Inc.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

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

D. Dielectric-Flange Kits:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Central Plastics Company.
      d. Pipeline Seal and Insulator, Inc.

   2. 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.

E. Dielectric Couplings:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Calpico, Inc.
      b. Lochinvar Corporation.

   2. Description:
      a. Galvanized-steel coupling.
      b. Pressure Rating: 300 psig at 225 deg F.
      c. End Connections: Female threaded.
      d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Perfection Corporation; a subsidiary of American Meter Company.
2. Description:
   a. Electroplated steel nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig at 225 deg F End Connections: Male threaded or grooved.
   c. Lining: Inert and noncorrosive, propylene.

2.13 FLEXIBLE CONNECTORS

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

   1. Flex-Hose Co., Inc.
   2. Flexicraft Industries.
   3. Flex Pression, Ltd.
   4. Flex-Weld, Inc.
   5. Hyspan Precision Products, Inc.
   7. Metraflex, Inc.
   8. Proco Products, Inc.
   10. Unaflex, Inc.
   11. Universal Metal Hose; a Hyspan company

B. Bronze-Hose Flexible 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.

C. Stainless-Steel-Hose Flexible 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.

2.14 WATER METERS

A. Displacement-Type Water Meters:

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

      a. AALIANT; a Venture Measurement Product Line.
b. ABB.
c. Badger Meter, Inc.
d. Carlon Meter.
e. Mueller Company; Water Products Division.
f. Schlumberger Limited; Water Division.
g. Sensus Metering Systems.

2. Description:
   b. Pressure Rating: 150-psig working pressure.
   c. Body Design: Nutating disc; totalization meter.
   d. Registration: In gallons or cubic feet as required by utility.
   e. Case: Bronze.
   f. End Connections: Threaded.

B. Turbine-Type Water Meters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. AALIANT; a Venture Measurement Product Line.
      b. ABB.
      c. Badger Meter, Inc.
      d. Hays Fluid Controls.
      e. Master Meter, Inc.
      f. McCrometer.
      g. Mueller Company; Water Products Division.
      h. Schlumberger Limited; Water Division.
      i. SeaMetrics Inc.
      j. Sensus Metering Systems.

   2. Description:
      b. Pressure Rating: 150-psig working pressure.
      c. Body Design: Turbine; totalization meter.
      d. Registration: In gallons or cubic feet as required by utility company.
      e. Case: Bronze.
      f. End Connections for Meters NPS 2 and Smaller: Threaded.
      g. End Connections for Meters NPS 2-1/2 and Larger: Flanged.

C. Compound-Type Water Meters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABB.
      b. Badger Meter, Inc.
      c. Master Meter, Inc.
      d. Mueller Company; Water Products Division.
2. Description:
   b. Pressure Rating: 150-psig working pressure.
   c. Body Design: With integral mainline and bypass meters; totalization meter.
   d. Registration: In gallons or cubic feet as required by utility company.
   e. Case: Bronze.

D. Fire-Service-Type Water Meters:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Badger Meter, Inc.
      b. Mueller Company; Water Products Division.
      c. Schlumberger Limited; Water Division.
      d. Sensus Metering Systems.
   2. Description:
      a. Standard: AWWA C703 and UL listing.
      b. Pressure Rating: 175-psig working pressure.
      c. Body Design:
         1) Proportional, Detector-Type Water Meters: With meter on bypass.
            a) Bypass Meter: AWWA C701, turbine type with bronze case; size not less than one-half nominal size of main-line meter.
         2) Turbine-Type Water Meters: With strainer, and with meter on bypass.
            a) Strainer: Full size, matching water meter.
            b) Bypass Meter: AWWA C701, turbine type with bronze case; not less than NPS 2.
      d. Registration: In gallons or cubic feet as required by utility company.
      e. Case: Bronze.
      f. Pipe Connections for Meters NPS 2 and Smaller: Threaded.
      g. Pipe Connections for Meters NPS 2-1/2 and Larger: Flanged.

E. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

F. Remote Registration System: Encoder type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.
2.15 ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
B. One Piece, Cast Brass: Polished, chrome-plated or rough-brass finish with setscrews.
D. One Piece, Stamped Steel: Chrome-plated finish with setscrew or spring clips.
E. Split Casting, Cast Brass: Polished, chrome-plated or rough-brass finish with concealed hinge and setscrew.
F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew.
G. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
H. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.16 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped and smooth outer surface with nailing flange for attaching to wooden forms.
D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.
E. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
F. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.
G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with setscrews.

2.17 SLEEVE SEALS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Advance Products & Systems, Inc.
   2. Calpico, Inc.
   3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.18 WALL PENETRATION SYSTEMS

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

1. SIGMA.

B. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.

1. Carrier-Pipe Deflection: Up to 5 percent without leakage.
2. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
3. Housing-to-Sleeve Gasket: EPDM rubber.

2.19 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi, 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
3.2 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 ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section 221119 "Domestic Water Piping Specialties" for drain valves and strainers.

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

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for pressure-reducing valves.

H. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

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

J. Install seismic restraints on piping. Comply with requirements in Section 230540 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

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

L. 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.

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

N. Install piping adjacent to equipment and specialties to allow service and maintenance.

O. Install piping to permit valve servicing.

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

Q. Install piping free of sags and bends.
R. Install fittings for changes in direction and branch connections.
S. Install PEX piping with loop at each change of direction of more than 90 degrees.
T. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

3.3 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 pipes, tubes, and fittings before assembly.
C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
F. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
G. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.
H. 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.
I. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.
J. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.
L. 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.

M. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Piping: Join according to ASTM D 2855.

N. PEX Piping Joints: Join according to ASTM F 1807.

O. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 VALVE INSTALLATION

A. General-Duty Valves: Comply with requirements in Section 230523 "General-Duty Valves for Plumbing Piping" for valve installations.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Section 221119 "Domestic Water Piping Specialties."

1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves for piping NPS 2 and smaller and butterfly valves for piping NPS 2-1/2 and larger. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for balancing valves.

E. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for calibrated balancing valves.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:
1. NPS 1-1/2 and Smaller: Fitting-type coupling.
2. NPS 2 and Larger: Sleeve-type coupling.

C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.6 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.

3.7 FLEXIBLE CONNECTOR INSTALLATION

A. Install flexible connectors in suction and discharge piping connections to each domestic water pump.
B. Install bronze-hose flexible connectors in copper domestic water tubing.
C. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.8 WATER METER INSTALLATION

A. Rough-in domestic water piping for water meter installation according to utility company's requirements.
B. Water meters will be furnished and installed by utility company.
C. Install water meters according to AWWA M6, utility company's requirements, and the following:
D. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
E. Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
F. Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
G. Install fire-service water meters with shutoff valves on water-meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.
H. Install remote registration system according to standards of utility company and of authorities having jurisdiction.

3.9 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 230540 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

B. Comply with requirements in Section 230529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and 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.
      c. Longer Than 100 Feet If Indicated: MSS Type 49, spring cushion rolls.
   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.

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

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

E. 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-inch rod.
   2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
   3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   4. NPS 2-1/2: 108 inches with 1/2-inch rod.
   5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
   6. NPS 6: 10 feet with 5/8-inch rod.
   7. NPS 8: 10 feet with 3/4-inch rod.

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

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

   1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
   2. NPS 1-1/2: 108 inches with 3/8-inch rod.
   3. NPS 2: 10 feet with 3/8-inch rod.
   4. NPS 2-1/2: 11 feet with 1/2-inch rod.
   5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
   6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
   7. NPS 6: 12 feet with 3/4-inch rod.
   8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.
H. Install supports for vertical steel piping every 15 feet.

I. Install vinyl-coated hangers for CPVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 36 inches with 3/8-inch rod.
2. NPS 1-1/4 to NPS 2: 48 inches with 3/8-inch rod.
3. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
4. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
5. NPS 6: 48 inches with 3/4-inch rod.
6. NPS 8: 48 inches with 7/8-inch rod.

J. Install supports for vertical CPVC piping every 60 inches for NPS 1 and smaller, and every 72 inches for NPS 1-1/4 and larger.

K. Install vinyl-coated hangers for PEX piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.

L. Install hangers for vertical PEX piping every 48 inches.

M. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
2. NPS 2-1/2 to NPS 3-1/2: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6: 48 inches with 3/4-inch rod.
5. NPS 8: 48 inches with 7/8-inch rod.

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

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

3.10 CONNECTIONS

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

B. Install piping adjacent to equipment and machines to allow 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 required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.

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.

3.11 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.

B. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish.
   5. Bare Piping in Equipment Rooms: One piece, cast brass.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

C. Escutcheons for Existing Piping:
   2. Insulated Piping: Split plate, stamped steel with concealed hinge and spring clips.
   3. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
   4. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with chrome-plated finish.
   5. Bare Piping in Unfinished Service Spaces: Split casting, cast brass with polished chrome-plated finish.
   6. Bare Piping in Equipment Rooms: Split casting, cast brass.
   7. Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting floor plate.

3.12 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.
F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants" for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants" for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Molded PE [Molded PVC] [Steel pipe]
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: [Steel pipe] [Stack sleeve fittings]
   b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to [2 inches] above finished floor level. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim" for flashing.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   a. [PVC pipe] [Steel pipe] sleeves for pipes smaller than NPS 6.
   b. [Galvanized-steel sheet] sleeves for pipes NPS 6 and larger.
   c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Concrete Roof Slabs: [Molded PE] [Molded PVC] [Steel pipe]

5. Sleeves for Piping Passing through Exterior Concrete Walls:
   a. [Steel pipe] sleeves for pipes smaller than NPS 6.
   b. [Cast-iron wall pipe] sleeves for pipes NPS 6 and larger.
   c. Install sleeves that are large enough to provide [1-inch] annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
   d. Do not use sleeves when wall penetration systems are used.

6. Sleeves for Piping Passing through Interior Concrete Walls:
   a. [PVC pipe] [Steel pipe] sleeves for pipes smaller than NPS 6.
   b. [Galvanized-steel sheet] sleeves for pipes NPS 6 and larger.
L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.13 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.14 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.15 IDENTIFICATION

A. Identify system components. Comply with requirements in Section 230550 "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.16 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.

2. 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:

   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. **Reports:** Prepare inspection reports and have them signed by authorities having jurisdiction.

**C. Piping Tests:**

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. 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.
3. 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.
4. 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 standing for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
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 for corrective action required.

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

**E. Prepare test and inspection reports.**

**3.17 ADJUSTING**

**A. Perform the following adjustments before operation:**

1. Close drain valves, hydrants, and hose bibs.
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 flow of hot water 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.

**3.18 CLEANING**

**A. Clean and disinfect potable and non-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.
      
      2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
      
      c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
      
      d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Clean non-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 procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
      
      a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
      
      b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

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

3.19 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-building-slab, domestic water, building service piping, [NPS 3 and smaller], shall be [one of] the following:
1. Soft copper tube, [ASTM B 88, Type K] [ASTM B 88, Type L]; [wrought-copper solder-joint fittings; and brazed] [copper pressure-seal fittings; and pressure-sealed] joints.
2. PVC, [Schedule 40 pipe; PVC, Schedule 40] [Schedule 80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.

E. Under-building-slab, domestic water, building-service piping, [NPS 4 to NPS 8 and larger] shall be [one of] the following:

1. Soft copper tube, [ASTM B 88, Type K] [ASTM B 88, Type L]; wrought-copper solder-joint fittings; and brazed joints.
2. Mechanical-joint, ductile-iron pipe; [standard-] [or] [compact-] pattern mechanical-joint fittings; and mechanical joints.
3. Push-on-joint, ductile-iron pipe; [standard-] [or] [compact-] pattern push-on-joint fittings; and gasketed joints.
4. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
5. PVC, [Schedule 40 pipe; PVC, Schedule 40] [Schedule 80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.

F. Under-building slab, combined domestic water, building-service, and fire-service-main piping, [NPS 6 to NPS 12] shall be [one of] the following:

1. Mechanical-joint, ductile-iron pipe; [standard-] [or] [compact-] pattern mechanical-joint fittings; and mechanical joints.
2. Push-on-joint, ductile-iron pipe; [standard-] [or] [compact-] pattern push-on-joint fittings; and gasketed joints.
3. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

G. Under-building-slab, domestic water piping, [NPS 2 and smaller], shall be [one of] the following:

1. [Hard] [Hard or soft] [Soft] copper tube, ASTM B 88, Type L; [wrought-copper solder-joint fittings; and brazed] [copper pressure-seal-joint fittings; and pressure-sealed] joints.
2. PVC, [Schedule 40 pipe; PVC, Schedule 40] [Schedule 80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.

H. Aboveground domestic water piping, [NPS 2 and smaller] shall be[ one of] the following:

1. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
2. Hard copper tube, [ASTM B 88, Type L] [ASTM B 88, Type M]; [cast-] [or] [wrought-] copper solder-joint fittings; and [brazed] [soldered] joints.
3. Hard copper tube, [ASTM B 88, Type L] [or] [ASTM B 88, Type M]; copper pressure-seal-joint fittings; and pressure-sealed joints.
4. Hard copper tube, [ASTM B 88, Type L] [or] [ASTM B 88, Type M ]; copper push-on-joint fittings; and push-on joints.
5. CPVC, [Schedule 40 pipe; CPVC, Schedule 40] [Schedule 80 pipe; CPVC, Schedule 80] socket fittings; and solvent-cemented joints.
6. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
7. CPVC Tubing System: CPVC tube; CPVC socket fittings; and solvent-cemented joints. [NPS 1-1/2 and NPS 2 CPVC pipe with CPVC socket fittings may be used instead of tubing.]

8. PEX Tube, NPS 1 and smaller; fittings for PEX tube; and crimped joints.

9. PVC, [Schedule 40 pipe; PVC, Schedule 40] [Schedule 80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.

I. Aboveground domestic water piping, [NPS 2-1/2 to NPS 4] shall be [one of] the following:

1. Hard copper tube, [ASTM B 88, Type L] [ASTM B 88, Type M]; [cast-] [or] [wrought-] copper solder-joint fittings; and [brazed] [soldered] joints.
2. Hard copper tube, [ASTM B 88, Type L] [or] [ASTM B 88, Type M]; copper pressure-seal-joint fittings; and pressure-sealed joints.
3. Hard copper tube, [ASTM B 88, Type L] [or] [ASTM B 88, Type M]; grooved-joint copper-tube appurtenances; and grooved joints.
4. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
5. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
6. CPVC, [Schedule 40 pipe; CPVC, Schedule 40] [Schedule 80 pipe; CPVC, Schedule 80] socket fittings; and solvent-cemented joints.
7. CPVC, Schedule 80 pipe; CPVC, Schedule 80 threaded fittings; and threaded joints.
8. PVC, [Schedule 40 pipe; PVC, Schedule 40] [Schedule 80 pipe; PVC, Schedule 80] socket fittings; and solvent-cemented joints.

J. Aboveground domestic water piping, [NPS 5 to NPS 8] shall be [one of] the following:

1. Hard copper tube, [ASTM B 88, Type L] [ASTM B 88, Type M]; [cast-] [or] [wrought-] copper solder-joint fittings; and [brazed] [soldered] joints.
2. Hard copper tube, [ASTM B 88, Type L] [or] [ASTM B 88, Type M]; grooved-joint copper-tube appurtenances; and grooved joints.
3. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
4. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.

K. Aboveground, combined domestic-water-service and fire-service-main piping, [NPS 6 to NPS 12] shall be [one of] the following:

1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
2. Galvanized-steel pipe and nipples; galvanized, gray-iron threaded fittings; and threaded joints.
3. Galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.

3.20 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.

D. [CPVC] [and] [PVC] valves matching piping materials may be used.

END OF SECTION 221116
SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 QUALITY ASSURANCE
   A. Quality Standards: NSF 14 and NSF 61 Annex G.

1.2 PRODUCTS
   A. Vacuum Breakers:
      3. Pressure vacuum breakers.
      4. Spill-resistant vacuum breakers.
   B. Backflow Preventers:
      1. Intermediate Atmospheric-Vent Backflow Preventers:
         b. Finish: Chrome plated.
      2. Reduced-Pressure-Principle Backflow Preventers:
         a. Body: Bronze for NPS 2 and smaller; cast iron with interior lining for NPS 2-1/2 and larger.
         b. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
         c. Configuration: Horizontal, straight through.
      3. Double-Check Backflow-Prevention Assemblies:
         a. Body: Bronze for NPS 2 and smaller; cast iron with interior lining for NPS 2-1/2 and larger.
         b. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
         c. Configuration: Horizontal, straight through.
      4. Beverage-dispensing-equipment backflow preventers.
      5. Dual-check-valve backflow preventers.
      7. Reduced-Pressure-Detector, Fire-Protection Backflow-Preventer Assemblies:
         a. Body: Cast iron with interior lining.
b. Configuration: Horizontal, straight through.

8. Double-Check, Detector-Assembly Backflow Preventers:
   a. Body: Cast iron with interior lining.
   b. Configuration: Horizontal, straight through flow.


C. Water Pressure-Reducing Valves:

1. Water Regulators:
   a. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
   c. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

2. Water Control Valves:
   a. Main Valve Body: Angle-valve design.
   b. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

D. Balancing Valves:

2. Cast-iron calibrated balancing valves.
3. Accessories: Meter kit.
4. Memory-stop balancing valves.

E. Temperature-Actuated Water Mixing Valves:

1. Water-Temperature Limiting Devices:
   a. Connections: Threaded union inlets and outlet.
   b. Finish: Chrome plated.

2. Primary, Thermostatic, Water Mixing Valves:
   a. Type: Exposed mounted.
   b. Connections: Threaded union inlets and outlet.
   c. Finish: Chrome plated.
   d. Piping: Chrome plated.
   e. Cabinet: Recessed mounted.

3. Manifold, Thermostatic, Water-Mixing-Valve Assemblies:
a. Description: Cabinet-type assembly in two-valve parallel arrangement.
b. Cabinet: Recessed mounted.
c. Finish: Chrome plated.
d. Piping: Chrome plated.

5. Individual-fixture, water tempering valves.
6. Primary water tempering valves.

F. Strainers for Domestic Water Piping:

1. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and larger.
2. Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
3. Screen: Stainless steel with round perforations unless otherwise indicated.

G. Outlet Boxes:

1. Clothes Washer Outlet Boxes:
   b. Inlet Hoses: Two, 60 inches long.
   c. Drain Hose: One, 48 inches long.

2. Icemaker Outlet Boxes: [enameled-steel or epoxy-painted-steel] [enameled-steel or epoxy-painted-steel or plastic] [Plastic] [Stainless-steel] box and faceplate.

H. Hose Stations:

1. Single-Temperature-Water Hose Stations:
   a. Body: Bronze with stainless-steel wetted parts.
   b. Finish: Rough bronze, chrome plated.
   c. Mounting: Wall, with reinforcement
   d. Hose: 50 feet long.

2. Hot- and Cold-Water Hose Stations:
   a. Type Faucet: Blending valve.
   b. Body: Bronze with stainless-steel wetted parts.
   c. Finish: Rough bronze.
   d. Mounting: Wall, with reinforcement.
   e. Hose: 50 feet long.

I. Hose Bibbs:

2. Finish for Service Areas: Rough bronze.
3. Operation for Service Areas: Wheel handle.
4. Operation for Finished Rooms: Wheel handle.
5. Wall flange with each chrome- or nickel-plated hose bibb.

J. Wall Hydrants:

1. Nonfreeze Wall Hydrants:
   a. Outlet: Concealed.
   b. Finish: Polished nickel bronze.

2. Nonfreeze, Hot- and Cold-Water Wall Hydrants:
   a. Outlet: Concealed.
   b. Finish: Polished nickel bronze.

3. Moderate-Climate Wall Hydrants:
   a. Outlet: Concealed.
   b. Finish: Polished nickel bronze.


K. Ground Hydrants:

1. Box: Standard pattern with cover.
2. Box and Cover Finish: Rough bronze.

L. Post Hydrants:

1. Nonfreeze, draining-type post hydrants.
2. Nonfreeze, nondraining-type post hydrants.

M. Drain Valves: Ball-valve type.

N. Water Hammer Arresters: Metal bellows.

O. Air Vents: Bolted construction.

P. Trap-Seal Primer Valves: Supply type.

1.3 MANUFACTURED UNITS

A. Trap-Seal Primer Systems:
   1. Cabinet: Recessed-mounted steel box with stainless-steel cover.
   2. Number Outlets: Four.

B. Water Meters: Displacement type.
END OF SECTION 221119
SECTION 221300 - SANITARY SEWERAGE 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: Work under this section includes:

1. Pipe, tube, and fittings.
2. Cleanouts.
3. Floor drains.
4. Trench drains.
5. Miscellaneous sanitary drainage piping specialties.
6. Flashing materials.
7. Oil/water separators.

B. Related Sections: Section 220500 "Common Work for Plumbing."

1.3 DEFINITIONS

B. FRP: Fiberglass-reinforced plastic.
C. HDPE: High-density polyethylene plastic.
D. PE: Polyethylene plastic.
E. PP: Polypropylene plastic.
F. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

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


B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1.5 SUBMITTALS

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

1. Pipe, tube, and fittings.
2. Cleanouts.
3. Floor drains.
4. Trench drains.
5. Miscellaneous sanitary drainage piping specialties.
6. Flashing materials.
7. Oil/water separators.

1.6 QUALITY ASSURANCE

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


PART 2 - PRODUCTS

2.1 PIPING SCHEDULE

A. Aboveground, soil and waste piping shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
3. Copper DWV tube, copper drainage fittings, and soldered joints.

B. Aboveground, vent piping shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
4. Stainless-steel pipe and fittings, sealing rings, and gasketed joints.
5. Copper DWV tube, copper drainage fittings, and soldered joints.
7. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Underground, soil, waste, and vent piping shall be one of the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.
2. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

D. Sanitary Piping Outside Building:

1. From inside face of building to a distance of approximately 5 feet outside of building and underground inside building, sanitary and storm drain pipe shall be cast iron soil pipe conforming to ASTM A888-04a, ASTM A74, or CISPI 301-04a.

2. A suitable adapter connector for interfacing with exterior drainage piping shall be provided.

E. Condensate Drain Piping: Condensate drain piping serving drain pans and cooling coil drain shall be ASTM B306 hard temper copper drainage tubing (DWV) with ANSI/ASME B16.23 cast bronze fittings.

2.2 CAST IRON SANITARY WASTE AND VENT PIPING

A. Standard of Quality: All cast iron sanitary, waste and vent piping shall bear the marking of Cast Iron Soil Pipe trademark, and shall be manufactured in the United States. All the above products shall be listed with IAPMO under file numbers:

1. No. 2862 Couplings
2. No. 3209 Closet Bends
3. No. 3270 Cast Iron Soil Pipe and Fittings - No Hub and Service Weight.

2.3 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.

2.4 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

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

B. Heavy-Duty, Hubless-Piping Couplings:

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. ANACO-Husky.
   b. Clamp-All Corp.
   c. MIFAB, Inc.
   d. Tyler Pipe.

3. Description: Type 304 stainless steel full shielded couplings having 2 stainless steel bands and tightening clamps for pipe sizes 1-1/2" through 4" and 4 stainless steel bands and tightening clamps for pipe sizes 5" through 10", and 6 stainless steel bands and tightening clamps for pipe sizes 12" through 15"; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.5 GALVANIZED-STEEL PIPE AND FITTINGS

A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight class. Include square-cut-grooved or threaded ends matching joining method.


C. Steel Pipe Pressure Fittings:

D. Cast-Iron Flanges: ASME B16.1, Class 125.
   1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.6 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, water tube, drawn temper.

D. 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.

E. 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, 1/8-inch maximum thickness unless thickness or specific material is indicated.
   2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
F. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.7 ABS PIPE AND FITTINGS

A. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.

B. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.

   1. ABS solvent cement shall have a VOC content of 325 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."

2.8 PVC PIPE AND FITTINGS

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

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. 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."

D. 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."

2.9 CLEANOUTS

A. General Requirements for Cleanouts: Cleanouts shall be same size as the pipe, up to 4"; not less than 4" for larger pipe. Cleanouts shall be easily accessible. Provide a minimum clearance of 24 inches to facilitate rodding. Cleanouts shall be secured with vandal-proof screws.
   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:
b. MIFAB, Inc.
d. Tyler Pipe.
e. Watts Drainage Products.
f. Zurn Plumbing Products Group.

B. Cleanouts in Floors: Floor cleanouts shall have cast iron body and frame with square adjustable scoriated secured nickel bronze top. Unit shall be vertically adjustable for a minimum of 2". When a waterproof membrane is used in the floor system, provide clamping collars on the cleanouts. Cleanouts shall consist of "Y" fittings and 1/8 bends with brass or bronze screw plugs. Cleanouts in resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In carpeted areas, provide carpet cleanout markers.

C. Cleanouts in Vertical Piping: Provide cleanouts at or near the base of the vertical stacks with the cleanout plug located approximately 24" above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. Extend the cleanouts to the wall access cover. Cleanouts shall consist of sanitary tees. Provide stainless steel or chrome plated cover with minimum opening of 6" x 6" at each wall cleanout.

D. Cleanouts in Horizontal Piping: In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked no-hub cast iron ferrule. Plain end (no-hub) piping in interstitial spaces or above ceiling may use plain end (no-hub) blind plug and clamp.

2.10 FLOOR DRAINS

A. General Requirements:
1. Unless otherwise specified, all drains shall have cast-iron bodies. Drain outlet size, as indicated on the drawings.
2. Drains shall generally consist of a body; integral seepage pan and adjustable perforated or slotted strainer consisting of grate and threaded collar. Drains shall be of double pattern suitable for embedding in the floor construction. The seepage pan shall have weep holes or channels to permit drainage from the pan to the drainpipe.
3. All drains shall be provided with trap primer connections, except shower drains. Each drain shall be provided with a P-trap and vent.
4. Drains with integral no-hub outlets are acceptable.
5. Drain Flanges and Clamps: All drains installed in slabs that are not slab-on-grade shall include drainage flanges. All drains in membrane floors shall include flange and membrane clamping ring.
6. Finishes: Strainers of drains in showers shall be chrome-plated bronze or polished-nickel bronze; strainers in all finished areas, including stairwells, temporary unfinished areas, etc., shall be polished-nickel bronze. Strainers and grates in unfinished areas, such as boiler rooms and mechanical equipment rooms, shall be galvanized cast-iron or chromate converted cadmium or zinc electroplated coating, unless otherwise specified.

B. Drains-General Type:
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:
   b. MIFAB, Inc.
   d. Tyler Pipe.
   e. Watts Drainage Products.
   f. Wade.
   g. Zurn Plumbing Products Group.
   h. Jay R. Smith
   i. ACO

2. Floor Drain - General Service: Cast-iron body, flashing collar with protector cap, polished-nickel bronze adjustable strainer head with heel-proof grate and trap primer connection. Minimum size strainers for the following outlet pipe sizes shall be provided unless otherwise specified: 5" strainer for 2" outlet; 6" strainer for 3" outlet; 8" strainer for 4" outlet. Manufacturer: Round top pattern Smith Fig 2010-A-NB, Josam 30000-A, Wade No.1100-STD-1, Zurn No. ZN-415 or approved Mifab. Square top pattern, Smith Fig. 2010-B, Josam 30000-S, Wade 1100-GK, Zurn No. ZN-415-S or approved Mifab.

C. Narrow, Sloped-Invert, Polymer-Concrete Channel Trench Drainage Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that shall be incorporated into the Work include the following:
   a. ACO Polymer Products, Inc., Model S100K.

2. Type: Modular system of channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling.

3. Channel Sections: Narrow, interlocking-joint, sloped-invert, polymer-concrete modular units with end caps. Include rounded bottom, with built-in invert slope of 0.6 percent and with outlets in number, sizes, and locations indicated. Include extension sections necessary for required depth.

4. Grates: Manufacturer's designation "heavy duty," Load Class F, with slots or perforations, and of width and thickness that fit recesses in channel sections.
   a. Material: Ductile iron.
   b. Covers: Solid ductile iron, of width and thickness that fit recesses in channel sections, and of lengths indicated.
   c. Supports, Anchors, and Setting Devices: Manufacturer's standard, unless otherwise indicated.
   d. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
   e. Grates shall be coated with factory standard black corrosion resistant coating. Provide additional enamel coating. Color to match Architect's sample.
2.11 ROOF FLASHING ASSEMBLIES

A. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 6 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

1. Open-top vent without cap.

2.12 DRAINAGE SPECIALTIES:

A. Air Gaps: Air gaps shall be cast bronze construction. Provide polished chrome-plated finish where exposed to view. Manufacturer: Zurn Z-1025 or Zurn Z-1025 (-CP), Josam 88900-CP, Smith Fig. 3955 or 3955 (-CP) Series or approved Wade or Mifab.

B. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping.

C. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
3. NPS 2: 4-inch minimum water seal.
4. NPS 2-1/2 and Larger: 5-inch minimum water seal.

D. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

2.13 OIL INTERCEPTORS

A. Steel Oil Interceptors:

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:
   b. MIFAB, Inc.
   d. Tyler Pipe.
   e. Watts Drainage Products.
   f. Zurn Plumbing Products Group.
2. Type: Factory-fabricated interceptor made for removing and retaining oil from wastewater.
5. Interior Lining: Corrosion-resistant enamel.
7. Extra Heavy-Duty Traffic Cover.

2.14 OUTSIDE SEWERS

A. General: Outside sanitary sewer work is specified in Division 33. Provide the building sewers to a point approximately five feet from building wall and make connection to outside utilities.

B. Ductile Iron Pipe and Fittings: Ductile iron pipe for sewer shall conform to ASTM A746, thickness class 51 unless otherwise shown or specified. Joints on pipe and fittings shall be push-on style and conform to AWWA C110 and AWWA C111, rated for 150 psi. Coordinate with Division 33 Contractor.

C. Support: Provide structural reinforced concrete beam support under sewers spanning the space between undisturbed the earth and building wall where piping enters the building. Beam shall rest on concrete corbel or structural steel shelf angle at building wall. Submit shop drawings for review.

PART 3 - EXECUTION

3.1 INSTALLATION, BUILDING DRAINAGE AND VENT PIPE PIPING SYSTEMS

A. General: Comply with all local code and Uniform Plumbing Code requirements for the installation of building drainage and vent piping unless otherwise indicated.

B. Installation of Floor Drains:

1. Floor drains shall be installed according to manufacturer's recommendations.
2. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.

G. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

H. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
   1. Exception: Fitting may be omitted if trap has trap-seal primer connection.

I. Install oil interceptors, including venting, according to authorities having jurisdiction and with clear space for servicing.

3.2 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.

D. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

3.3 TESTING AND ADJUSTING

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. 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 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.

E. Test of Drains: All floor drains, garage drains, trench or area drains shall be flow tested to demonstrate proper operation. All traps and sumps shall be cleaned out.

3.4 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 221300
SECTION 223000 - PLUMBING EQUIPMENT

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 the following:
   1. Commercial water softeners.
   2. Chemicals.
   3. Water-testing sets.
   4. Electric, tankless, domestic-water heaters.
   5. Domestic-water heater accessories.

1.3 SUBMITTALS

A. Product Data: Submit for each type and size of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Provide for the following:
   1. Water softeners.
   2. Chemicals.
   3. Water-testing sets.
   4. Domestic water heaters.
   5. Domestic-water heater accessories.
   6. Plumbing pumps.

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Manufacturer Seismic Qualification Certification: Submit certification that packaged booster pumps, accessories, and components will withstand seismic forces defined in Section 230540 "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

F. Operation and Maintenance Data: Include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. 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.

C. ASME Compliance:

1. ASME Compliance for Steel Tanks: Fabricate and label mineral tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, where indicated.

D. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

E. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

F. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Water Softener, Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softeners that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
a. Structural failures of mineral and brine tanks.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.
d. Attrition loss of resin exceeding 3 percent per year.
e. Mineral washed out of system during service run or backwashing period.
f. Effluent turbidity greater and color darker than incoming water.
g. Fouling of underdrain system, gravel, and resin with turbidity or by dirt, rust, or scale from water softener or soft water, while operating according to manufacturer's written operating instructions.

2. Residential Water Softeners, Warranty Period: From date of Substantial Completion.
   a. Tanks: Five years.
   b. Control Valve: One year.

3. Commercial Water Softeners, Warranty Period: From date of Substantial Completion.
   b. Brine Tanks: 10 years.
   c. Control Valve: One year.

B. Water Heater 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. Commercial, Electric, Storage, Domestic-Water Heaters:
      b. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
         1) Storage Tank: Three years.
         2) Controls and Other Components: Two years.
      c. Electric, Tankless, Domestic-Water Heaters: Two years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection: Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
2.2 COMMERCIAL WATER SOFTENERS

A. Manufacturers:

3. WaterSoft; a division of Amtrol, Inc.

B. Description: Factory-assembled, pressure-type water softener.

2. Configuration: [Single unit with one mineral tank] [Twin unit with two mineral tanks] [Triple unit with three mineral tanks] and one brine tank.
3. Wetted Components: Suitable for water temperatures from 40 to at least 120 deg F.
   a. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."
   b. Pressure Rating: 125 psig minimum.
   c. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
   d. Support Legs or Skirt: Constructed of structural steel, welded to tank.
   e. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
   f. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers, and arranged for even flow distribution through resin bed.
   g. Liner: PE, ABS, or other material suitable for potable water.

5. Mineral Tanks: Steel, electric welded; pressure-vessel quality.
   a. Construction: Fabricated and stamped to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."
   b. Pressure Rating: 125 psig minimum.
   c. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
   d. Finish: Exterior of tank spray-painted with rust-resistant prime coat, 2- to 3-mil dry film thickness. Interior sandblasted and lined with epoxy-polyamide coating, 8- to 10-mil dry film thickness.
   e. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
   f. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers, and arranged for even flow distribution through resin bed.
   g. Liner: PE, ABS, or other material suitable for potable water.

6. Controls: Fully automatic; factory wired and factory mounted on unit.
   a. Adjustable duration of various regeneration steps.
   b. Push-button start and complete manual operation.
c. Metered control (with electric time clock and switch for backup) for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
d. Sequence of Operation: Multiport pilot-control valve automatically pressure-actuates main operating valve through steps of regeneration and return to service.
e. Pointer on pilot-control valve shall indicate cycle of operation.
f. Includes means of manual operation of pilot-control valve if power fails.

7. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

a. Slow opening and closing, nonslam operation.
b. Diaphragm guiding on full perimeter from fully open to fully closed.
c. Isolated, dissimilar metals within valve.
d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
e. Valve for single mineral-tank unit with internal automatic bypass of raw water during regeneration.
f. Sampling cocks for soft water.
g. Special tools are not required for service.

8. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressure; does not require field adjustments.

a. Meter Control: Each mineral tank is equipped with signal-register-head water meter that produces electrical signal indicating need for regeneration on reaching hand-set total in gallons. Signal will continue until reset.


a. Tank and Cover Material: Fiberglass, 3/16-inch-thick; or molded PE, 3/8 inch thick.
b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawal and freshwater refill.
c. Size: Large enough for at least four regenerations at full salting.

10. Factory-Installed Accessories:

a. Piping, valves, tubing, and drains.
b. Sampling cocks.
c. Main-operating-valve position indicators.
d. Water meters.

2.3 WATER SOFTENER CHEMICALS

1. Mineral: High-capacity, sulfonated-polystyrene, ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock salt is acceptable.
2.4 WATER-TESTING SETS

1. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions.

2.5 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Flow-Control, Electric, Tankless, Domestic-Water Heaters:

1. (Available) Manufacturers:
   b. Chronomite Laboratories, Inc.
   c. Eemax, Inc.
   d. Rheem

2. Standard: UL 499 for electric, tankless, domestic-water heater heating appliance.

3. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.
   b. Pressure Rating: [150 psig (1035 kPa)] <Insert value>.
   c. Heating Element: Resistance heating system.
   d. Temperature Control: Flow-control fitting.
   e. Safety Control: High-temperature-limit cutoff device or system.
   f. Jacket: Aluminum or steel with enameled finish or plastic.


2.6 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Expansion Tanks:

1. Manufacturers:

2. Manufacturers:
   a. AMTROL Inc.
   b. Armstrong Pumps, Inc.
   c. Honeywell Sparco
   d. Myers, F. E.; Pentair Pump Group (The)
   e. Smith, A. O.; Aqua-Air Div.
   f. State Industries, Inc.
   g. Taco, Inc.
   h. Watts Regulator Co.
   i. Wessels Co.

3. 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.
4. Construction:
   a. Tappings: 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.

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.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

D. Heat-Trap Fittings: ASHRAE 90.2.

E. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

F. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inches (457 mm) above the floor.

G. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.7 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:

   1. On-off status of each pump.
   2. Alarm status.

2.8 SOURCE QUALITY CONTROL

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

B. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

PART 3 - EXECUTION
3.1 WATER SOFTENER INSTALLATION

A. Equipment Mounting:
   1. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure.
   2. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.
   3. Prepare mineral-tank distribution system and underbedding for minerals and place specified mineral into mineral tanks.
   4. Provide water-testing sets near water softeners.

3.2 WATER SOFTENER CONNECTIONS

A. Where piping is installed adjacent to equipment, allow space for service and maintenance of equipment.

B. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank [and on inlet and outlet headers].
   1. Exception: Water softeners with factory-installed shutoff valves at locations indicated.

C. Install pressure gauges on raw-water inlet and soft-water outlet piping of each mineral tank.
   1. Exception: Water softeners with factory-installed pressure gauges at locations indicated.

D. Install valved bypass in water piping around water softeners if not factory installed within unit.

E. Install drains as indirect wastes to spill into open drains or over floor drains.

3.3 WATER HEATER INSTALLATION

A. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Install seismic restraints for water heaters. Anchor to substrate.

C. Install shutoff valves on cold-water-supply piping to water heaters and on hot-water outlet piping.

D. Install gas water heaters according to NFPA 54.

E. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

F. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
G. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

H. 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.

I. Install water heater drain piping to an indirect waste receptor or floor drain.

J. Install thermometer on outlet piping of water heaters.

K. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.

L. Fill water heaters with water.

M. Charge domestic-water expansion tanks with air.

3.4 PUMP INSTALLATION

A. Comply with HI 1.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Install centrifugal pumps with motor and pump shafts horizontal.

E. Install continuous-thread hanger rods and elastomeric hangers of sufficient size to support pump weight.

3.5 WATER HEATER CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Section 260526, "Grounding and Bonding."

D. Connect wiring according to Section 260519, "Electrical Power Conductors and Cables."

E. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.6 PUMP CONNECTIONS

A. Install piping adjacent to pumps to allow service and maintenance.

B. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Section 221116 "Domestic Water Piping."
   1. Install flexible connectors adjacent to pumps in suction and discharge piping of pumps.
   2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping.
   3. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

E. Connect [thermostats] [thermostats and timers] [timers] to pumps that they control.

F. Interlock pump with water heater burner and time delay relay.

3.7 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

D. Complete work and commission system as per 2015 Washington State Energy Code section C103.6 and C408.

END OF SECTION 223000
SECTION 224000 - PLUMBING FIXTURES

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. Lavatories.
2. Water closets.
4. Drinking fountains.
5. Water coolers.
6. Commercial sinks.
7. Outlet Boxes.
8. Flushometer valves.
9. Lavatory faucets.
10. Sink faucets.
11. Toilet seats.
12. Fixture supports.
13. Protective shielding guards.

1.3 DEFINITIONS


B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.
G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.


1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Operation and Maintenance Data: For plumbing fixtures 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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed or five of each, whichever is greater.

2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed or two of each, whichever is greater.

3. Flushometer-Tank Repair Kits: Equal to 5 percent of amount of each type installed or two of each, whichever is greater.

4. Toilet Seats: Equal to 5 percent of amount of each type installed or two of each, whichever is greater.

1.6 WATER EFFICIENCY STANDARDS

A. All applicable plumbing fixtures shall conform to the water efficiency standards set forth in the [Washington State amendments to] Chapter 4 of the Uniform Plumbing Code, latest addition.

1.7 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

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


E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
6. Vitreous-China Fixtures: ASME A112.19.2M.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.

I. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Disposers: ASSE 1008 and UL 430.
3. Floor Drains: ASME A112.6.3.
6. Off-Floor Fixture Supports: ASME A112.6.1M.
1.8 WARRANTY

A. Warranty Period for Commercial Applications: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

A. Lavatories: Rectangular vitreous china, wall hung, back ledge.

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

   b. Eljer, Inc.
   c. Kohler Co.
   d. Mansfield Plumbing Products, LLC.
   e. Bradley.
   f. Willoughby.


4. Holes: See PLUMBING FIXTURE SCHEDULE on Drawings for quantity and spacing of holes.

2.3 STAINLESS STEEL, WALL-MOUNTED LAVATORIES

A. Lavatories P3-2 Front access.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Willoughby Industries; ES-1015-HC-1 or a comparable product by one of the following:


2. Fixture:

   b. Material: 0.078-inch- (2.0-mm-) minimum-thick, 14 GA type 304 stainless steel.
   c. Finish: Exposed stainless steel surfaces polished to a No. 4 satin finish.
d. Receptor: Bowl with integral self-draining soap depression.
e. ADA Compliant: Yes.
g. Pushbuttons and Escutcheons: Machined type 303 stainless steel. No chrome-plated brass allowed.
h. Lavatory Water Supply Valve(s):
j. Valve Type: Pneumatic adjustable 5 to 90 seconds metering type with individual check stops.
k. Temperature: Single temperature.
l. Control: PB Pneumatic push-button.
m. Drain: Fast integral punched grid.
n. Trap: Removable NPS 1-1/2 (DN 40) complying with ASME A112.18.2/CSA B125.2.
o. Lavatory Overflow: Yes.

3. Accessories:
   a. Toothbrush Holders: None.
   b. Towel Hooks: None.
   c. Bubbler Location: On deck.

4. Anchoring hardware to be supplied by Contractor.
5. Electronic Controls: <None.

2.4 WATER CLOSETS

A. Water Closets: Wall mounted, top spud, vitreous china [accessible].

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   b. Crane Plumbing, L.L.C.
   c. Kohler Co.
   d. Mansfield Plumbing Products, LLC.
   e. Sloan.
   f. Toto.
   g. Willoughby.

2. Bowl:
   b. Bowl Type: Siphon jet.
   c. Rim Contour: Elongated.

3. Spud Size and Location: NPS 1-1/2; top.
4. Bowl-to-Drain Connecting Fitting: ASTM A 1045 or ASME A112.4.3.
5. Flushometer Valve: (FV-XX).
6. Support:
   a. Standard: ASME A112.6.1M.
   b. Description: Waste-fitting assembly as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. [Include additional extension coupling, faceplate, and feet for installation in wide pipe space.]

B. Water Closets, P1-2, Carrier mounted wall outlet.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Willoughby Industries; ETW-1490-CMo or a comparable product by one of the following:
   a) Acorn Engineering Company.

3. Material: 0.078-inch- (2.0-mm-) minimum-thick, 14 GA type 304 stainless steel.
4. Finish: Exposed stainless steel polished to a No. 4 satin finish. Toilet bowl interior, bead-blast finished.
5. Water Closet:
   a) Bowl:
      Type: Elongated, with back inlet, integral trap, siphon-jet carrier mounted with contoured seat.
      Toilet Seat Rim Height: ADA.
      Seat Surface: No. 4 satin finish.
      Wall Outlet Connection: 3 or 4 bolt carrier for connection to toilet, supplied with gasket waste.
      Consumption: 1.28 GPF (4.8 LPF).
      Toilet Overflow Preventer: Manual reset vacuum-operated disabler with integral vacuum generator and integral bowl overflow sensor.
   b) Minimum Supply Pressure: 35 PSI (241 kPa) flowing.

6. Flushometer Valve: (FV-XX).

7. Electronic Controls: None.

2.1 WALL-HUNG URINALS

A. Urinals (U-XX): Wall hung, back outlet, washout accessible.

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   b. Crane Plumbing, L.L.C.
   c. Kohler Co.
d. Mansfield Plumbing Products, LLC.
e. Sloan.
f. Toto.

4. Type: Siphon jet with extended shields.
5. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
6. Flushometer Valve: (FV-XX).
7. Waste Fitting:

8. Support: ASME A112.6.1M, Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights.

2.2 MOP SINKS

A. Mop sink: Terrazzo, floor mounted.

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   b. Fiat Products.
   c. Florestone Products Co., Inc.
   d. Stern-Williams Co., Inc.

2. Fixture:
   b. Shape: Five sided.
   c. Tiling Flange: Not required.
   d. Rim Guard: Stainless steel, on front top surfaces.

3. Drain: Grid with NPS 3 outlet.
4. Mounting: On floor and flush to wall.
5. Faucet: (SSF-XX).

2.3 WATER COOLERS


1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   b. Elkay Manufacturing Co.
   c. Halsey Taylor.
   d. Haws Corporation.
2. Standards:
   a. Comply with NSF 61.
   b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
   c. Comply with ICC A117.1.
3. Description: ADA accessible wall-mounting water cooler and bottle filler.
5. Receptor Shape: Ledge top.
7. Bubblers: Two with adjustable stream regulator, located on deck and rear.
10. Drain: Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.2.
11. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
12. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
   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.

2.4 COMMERCIAL SINKS

A. Commercial Sinks Single Compartment, (S-XX):
   1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      a. Elkay Manufacturing Co.
      b. Just Manufacturing.
      c. Kindred.
      d. Sterling.
   2. Description: One-compartment, counter-mounting, stainless-steel commercial sink with backsplash.
   3. Fixture:

b. Overall Dimensions:  See PLUMBING FIXTURE SCHEDULE on drawings for sink dimensions.

c. Metal Thickness:  18 gauge.

d. Compartments:

1. Dimensions:  See PLUMBING FIXTURE SCHEDULE on drawings for compartment dimensions.

2. Drain:  3-1/2-inch crumb cup.

4. Faucet(s):  Sink (SF-XX).

   a. Number Required:  One.
   b. Mounting:  Deck.


   a. Drain Piping:  NPS 2 chrome-plated, cast-brass P-trap; waste to wall; [continuous waste;] and wall escutcheon(s).

7. Disposer:  (D-XX).

8. Dishwasher Air-Gap Fitting:  (AG-1).


11. Holes:  See PLUMBING FIXTURE SCHEDULE on Drawings for quantity and spacing of holes.

### 2.5 OUTLET BOXES

A. Water Outlet Boxes:

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

   b. Guy Gray Manufacturing Co., Inc.
   c. IPS Corporation.
   d. Oatey.
   e. Sioux Chief.


4. Faucet:  Valved fitting complying with ASME A112.18.1.  Include NPS 1/2 or smaller copper tube outlet.

5. Supply Shutoff Fitting:  NPS 1/2 ball valve and NPS 1/2 copper, water tubing.
2.6 FLUSHOMETER VALVES

A. Lever-Handle, Diaphragm Flushometer Valves, Water Closet:

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   a. Coyne & Delany Co.
   b. Mansfield Plumbing Products, LLC.
   c. Sloan Valve Company.
   d. Zurn Industries, LLC; Commercial Brass and Fixtures.
   e. Toto.

3. Minimum Pressure Rating: 125 psig
4. Flow Rate: As indicated on PLUMBING FIXTURE SCHEDULE.
5. Features: Integral check stop, backflow-prevention device.
7. Exposed Flushometer Valve Finish: Chrome plated.

2.7 LAVATORY FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

B. Lavatory Faucets: Single-control mixing valve.

1. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
   a. Chicago Faucets.
   b. Delta Faucet Company.
   c. Moen Incorporated.
   d. Speakman Company.
   e. Symmons.
   f. T & S Brass and Bronze Works, Inc.
   g. Zurn Plumbing Products Group.

7. Spout: Rigid type.
8. Spout Outlet: Aerator, 0.5 GPM.
10. Tempering Device: Mechanical.
2.8 SINK FAUCETS

A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

B. Sink Faucets: Manual type, Two-lever-handle mixing valve.

   a. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
      2. Chicago Faucets.
      3. Delta Faucet Company.
      5. Symmons Industries, Inc.

3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
5. Body Type: Centerset.
7. Finish: Polished chrome plate.
8. Handle(s): Lever.
10. Spout Type: Swing, solid brass.

2.9 TOILET SEATS

A. Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

2. Church Seats.
3. Olsonite Seat Co.
4. Sperzel of Lexington.

B. Standard: IAPMO/ANSI Z124.5.

C. Material: Plastic.

D. Type: Commercial (Standard).

E. Shape: Elongated rim, open front.
F. Hinge: Self-sustaining, check.

G. Hinge Material: Noncorroding metal.


2.10 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

B. Water-Closet Supports:

1. Description: Combination carrier designed for standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:

1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.

D. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

E. Sink Supports:

1. Description: II, sink carrier with hanger plate, bearing studs, and tie rod for sink-type fixture. Include steel uprights with feet.

2.11 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Subject to compliance with requirements, provide a product by one of the following:
a. Engineered Brass Co.
b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
c. McGuire Manufacturing Co., Inc.
d. Plumberex Specialty Products Inc.
e. TRUEBRO, Inc.
f. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

2. 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.

2.12 SUPPLY FITTINGS
A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
B. Standard: ASME A112.18.1/CSA B125.1.
C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
E. Operation: Wheel handle.
F. Risers:
   1. NPS 1/2.
   2. Chrome-plated, soft-copper flexible tube riser.

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 plumbing fixture installation.
B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION
A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture.

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

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install tanks for accessible, tank-type water closets with lever handle mounted on wide side of compartment.

N. Install toilet seats on water closets.

O. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

P. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

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

R. Install traps on fixture outlets.
   1. Exception: Omit trap on fixtures with integral traps.
   2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
S. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Section 220500 "Common Work Results for Plumbing."

T. Set service basins in leveling bed of cement grout. Grout is specified in Section 220500 "Common Work Results for Plumbing."

U. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Operate and adjust water dispensers and controls. Replace damaged and malfunctioning units and controls.
C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

D. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

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

3.8 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 224000
SECTION 230500 - COMMON WORK RESULTS 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. Requirements under this section includes required work that is common to multiple sections in Division 23 and shall be complied with by all suppliers and subcontractors.

1.3 DEFINITIONS
   A. A/E: Prime design consultant responsible for preparation of these specifications.
   B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
   C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
   D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
   E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
   F. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
   G. The following are industry abbreviations for plastic materials:
      1. CPVC: Chlorinated polyvinyl chloride plastic.
      2. PE: Polyethylene plastic.
      3. PVC: Polyvinyl chloride plastic.
   H. The following are industry abbreviations for rubber materials:
      1. EPDM: Ethylene-propylene-diene terpolymer rubber.
      2. NBR: Acrylonitrile-butadiene rubber.
1.4 SUBMITTALS

A. Provide submittals per Division 01, Section 013300, “Submittal Procedures.”

B. Product Data: Submit product data for each type of product indicated herein. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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

1. Required in the following areas: Mechanical Rooms, Pump Rooms, shafts, and congested areas required for coordination. Include as a minimum all piping and ductwork.
2. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Wiring Diagrams: For power, signal, and control wiring.

D. Operation and Maintenance Data:

1. All valves and specialty valves (Valve tag list),
2. Piping system accessories including, but not limited to; strainers, expansion tanks, meters, gages, thermometers, traps, filters, etc.
3. Ductwork system accessories including, but not limited to; fire and smoke dampers, backdraft dampers, terminal units, etc.
4. All equipment that includes an electrical connection and/or has recommended maintenance, along with all related accessories.
5. All controls.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.
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. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics (such as larger motor horsepower) may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 PROJECT CONDITIONS

A. Do not install products or materials that are wet, moisture damaged, or mold damaged.

B. Field Measurements: Verify actual dimensions of site conditions by field measurements before fabrication.

1.7 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.8 TRANSITIONS AND OFFSETS BEYOND THE SCOPE OF WORK

A. Check drawings of other trades to verify spaces in which work will be installed. Establish exact locations of piping and ducts in such a manner as to conform to structure, avoid obstructions, and keep openings and passageways clear. Lines that must pitch, or that must have a constant elevation, shall have the right-of-way over lines not so restricted. Maintain maximum headroom. If space conditions appear inadequate, notify the A/E before proceeding with the work. Make reasonable modifications in the work without extra cost as needed to prevent conflict with work of other trades and for proper execution of the work.

B. If the total additional weight of sheet metal or piping materials (including associated fittings, hangers, seismic restraints and insulation) required for piping offsets which are not indicated or inferred on the contract documents exceeds nine percent (9%) of the total weight of the piping system, the amount exceeding this percentage may be considered to be beyond the requirements of these documents.

C. In order for additional compensation to be considered for transitions and offsets in excess of the amount stated in Paragraph B above, the Contractor shall submit to the A/E a detailed take-off of all materials indicated on the contract documents. The Contractor shall also submit a separate take-off along with coordination drawings or marked-up contract drawings with yellow highlighting indicating specifically the transitions and offsets considered to be "extra work." Additional compensation will only be considered if take-offs and drawings are received by the A/E four weeks in advance of the fabrication of conflicting work in the area of concern so that the A/E may be able to determine ways to minimize or eliminate the extra work.
1.9 COORDINATION

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

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08.

PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND EQUIPMENT SUPPORTS

A. Description: MSS SP-58-2009; “Pipe Hangers and support– Materials, Design, Manufacture, Selection, Application and Installation”: Types 1 through 59, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

2. Manufacturers:
   a. Anvil.
   b. B-Line Systems, Inc.
   c. ERICO/Michigan Hanger Co.
   d. Hubbard Enterprises/HOLDRITE®
   e. PHD Manufacturing, Inc.

B. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts. For piping 2” and below, manufactured specialty products formed from pre-galvanized commercial steel.

1. The total weight of piping and components upon each trapeze span shall not exceed the manufacturers load rating. Load ratings must include a minimum 2 X safety factor.
   a. Hubbard Enterprises/HOLDRITE EZ-Strut™ or owner approved equivalent.
2.3 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

2. Manufacturers:
   b. ERICO/Michigan Hanger Co.; ERISTRUT Div.
   c. Hubbard Enterprises/HOLDRITE®
   d. PHD Manufacturing, Inc.
   e. Unistrut Corp.; Tyco International, Ltd.

B. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.4 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

2. Manufacturers:
   a. Carpenter & Paterson, Inc.
   b. ERICO/Michigan Hanger Co.
   c. Pipe Shields, Inc.

B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated or stainless steel, for use in hardened Portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2. Manufacturers:
   a. Hilti, Inc.
   b. Hubbard Enterprises/HOLDRITE®
   c. ITW Ramset/Red Head.
   d. Powers Fasteners.

2.6 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

1. Basis of Design: MIRO Industries
2. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.

B. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:
   a. MIRO Industries.

C. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Basis of Design: MIRO Industries
2. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.
   c. Portable Pipe Hangers.

4. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
5. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

D. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:
   a. Portable Pipe Hangers.

2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

E. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

2. Manufacturers:
   b. HOLDRITE Corp.; Hubbard Enterprises.
   c. Samco Stamping, Inc.

2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Plenum Rated Pipe Clamps: ASTM E-84 25/50 plastic clamps from Hubbard Enterprises/HOLDRITE.

C. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.

2.10 EXPANSION COMPENSATORS

A. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Metraflex Metraloop
   b. Flex-Hose Co., Inc.
   c. Flexicraft Industries.
2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder joint end connections.
   a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
   b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.
   a. NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
   b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
   c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.

2.11 ALIGNMENT GUIDES

   A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      a. Metraflex, Inc.
      b. Flex-Hose Co., Inc.
      c. Flexicraft Industries.
      d. Flex-Weld, Inc.
      e. Hyspan Precision Products, Inc.

2.12 MATERIALS FOR ANCHORS

   A. Indicate alignment-guide length and maximum spider travel on Drawings.
   
   B. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.
   
   C. Steel Shapes and Plates: ASTM A 36/A 36M.
   
   D. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
   
   E. Washers: ASTM F 844, steel, plain, flat washers.
   
   F. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
2. Expansion Plug: Zinc-coated steel.

G. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

H. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

I. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi, 28-day compressive strength.

2.13 THERMOMETERS

A. Manufacturer:

2. Marsh Bellofram/Marshalltown.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Miljoco.


1. Case: Highly polished, hermetically sealed, stainless steel with 5-inch diameter.
2. Element: Bimetal coil.
3. Dial: Satin-faced, or highly polished, non-reflective aluminum with permanently etched scale markings.
6. Stem: stainless steel, for thermo-well installation and of length to suit installation.
7. Accuracy: Plus or minus one percent of range or plus or minus one scale to maximum of 1.5 percent of range. Scale shall be degrees Fahrenheit, unless otherwise indicated, suitable for the media operating temperatures.
8. Thermometers shall conform generally to the following:

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>RANGE – DEGREES F.</th>
<th>DEG. F/DIV.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Hot Water</td>
<td>30-240</td>
<td>2</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>30-130</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>--------</td>
<td>-----</td>
</tr>
<tr>
<td><strong>Chilled Water</strong></td>
<td>0-100</td>
<td>1</td>
</tr>
<tr>
<td><strong>Steam and Condensate</strong></td>
<td>50 to 400</td>
<td>2</td>
</tr>
<tr>
<td><strong>Air Ducts</strong></td>
<td>40 to 120</td>
<td>1</td>
</tr>
</tbody>
</table>

C. Thermowells: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer with extension necks of suitable length for insulated piping. Furnished by same manufacturer as thermometers.

1. Threaded Stainless Steel
2. Pressure Rating – not less than piping system design pressure.
3. Stem Length – Extend 2” into fluid or to extend to center of pipe
4. Extension for insulated piping – 2” nominal but not less than thickness of insulation
5. Threaded cap nut – With chain permanently fastened to well and cap.

2.14 PRESSURE GAUGES

A. Manufacturers:

2. Marsh Bellofram/Marshalltown
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Miljoco

B. Direct-Mounting, Dial-Type Pressure Gages:

1. Indicating-dial type complying with ASME B40.100.
2. Case: Liquid-filled type, 4-1/2-inch diameter Grade A Phosphor Bronze.
3. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
4. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Ring: Stainless steel.
8. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
9. Range for Fluids under Pressure: Two times operating pressure.
10. Scale: Scale shall be psig.

C. Shutoff Cocks for Gauges: 1/4” NPT lever handle ball valve with solid chrome-plated brass ball. Same manufacturer as gauge.

D. Pressure Snubbers: Filter type snubbing element, brass housing. Same manufacturer as gauge.

2.15 TEST PLUGS

A. Manufacturers

1. Peterson Equipment Co., Inc.
2. Sisco Manufacturing Co.
3. Or equal.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem beyond insulation for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200-degree F.

D. Core Inserts: One or two self-sealing neoprene, valves gasketed orifice, suitable for inserting a 1/8” OD probe assembly.
   1. Insert material for air, water, oil, or gas service at 20 to 200-degree F shall be CR.
   2. Insert material for air or water service at minus 30 to plus 275-degree F shall be EPDM.

2.16 HEAT TRACING

A. General
   1. Furnish and Install a complete UL Listed, CSA Certified, or FM Approved system of heating cables, components, and controls to (choose one: prevent pipes from freezing, provide freeze protection of sprinkler system piping, provide flow maintenance of grease lines, provide flow maintenance for fuel oil).

B. Materials
   1. The self-regulating heating cable shall consist of two (2) 16 AWG nickel-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heating cable to be cut to length in the field. The heating cable shall be covered by a radiation-crosslinked, modified polyolefin dielectric jacket. To provide a ground path and to enhance the heating cable’s ruggedness, the heating cable shall have a braid of tinned copper and an outer jacket of (select: modified polyolefin (-CR) or fluoropolymer (-CT)), as required per section 427-23 of the NEC-1996. For installation on plastic piping, the heating cable shall be applied using aluminum tape (AT-180).
   2. In order to conserve energy and to prevent overheating, the heating cable shall have a self-regulating factor of at least 90 percent. The self-regulation factor is defined as the percentage reduction, without thermostatic control, of the heating cable output going from 40°F pipe temperature operation to 150°F pipe temperature operation.
   3. The heating cable shall operate on line voltages of (select: 120, 208, 220, 240, or 277) volts without the use of transformers.
   4. The heating cable for metal-pipe freeze protection shall be sized according to the table below. The required heating cable output rating is in watts per foot at 50°F. (Heating cable selection based on 1-inch fiberglass insulation on metal piping.)

<table>
<thead>
<tr>
<th>Minimum Ambient Temperature</th>
<th>0°F</th>
<th>-20°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe size (inches)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 or less</td>
<td>5 watts</td>
<td>5 watts</td>
</tr>
<tr>
<td>4</td>
<td>5 watts</td>
<td>8 watts</td>
</tr>
<tr>
<td>6</td>
<td>8 watts</td>
<td>8 watts</td>
</tr>
<tr>
<td>8</td>
<td>8 watts</td>
<td>2 strips–5 watts</td>
</tr>
</tbody>
</table>
5. The heating cable shall be XL-Trace cable as manufactured by Raychem Corporation.
6. Power connection, end seal, splice, and tee kit components shall be applied in the field.
7. Heating cable circuit shall be protected by a ground-fault device for equipment protection. This requirement is in accordance with section 427-22 of the NEC-1996.

C. Components

1. All heating-cable components shall be UL Listed, CSA Certified, or FM Approved for use as part of the system to provide (choose one: pipe freeze protection, flow maintenance). Component enclosures shall be rated NEMA 4X to prevent water ingress and corrosion. Installation shall not require the installing contractor to cut into the heating-cable core to expose the bus wires. Connection systems that require the installing contractor to strip the bus wires or that use crimps or terminal blocks, shall not be acceptable. All components that make an electrical connection shall be reenterable for servicing. No component shall use silicone to seal the electrical connections. An exception will be made in areas where a conduit transition is required.

D. System Control

1. Option 1: Manual Control
   a. The system shall be controlled by a switch, either directly or through an appropriate contactor.

2. Option 2: Thermostatic Control–Ambient Sensing
   a. The system shall be controlled by an ambient sensing thermostat (choose: AMC-1A or AMC-F5) set at 40°F either directly or through an appropriate contactor.

3. Option 3: Thermostatic Control–Line Sensing
   a. The system shall be controlled by a line sensing thermostat (choose: AMC-F5 fixed at 40°F or AMC-1B variable set point) set at 40°F either directly or through an appropriate contactor.

E. Execution

1. Installation:
   a. A. System must be installed per manufacturer’s recommendations.
   b. B. Apply the heating cable linearly on the pipe after piping has been successfully pressure-tested.
   c. Secure the heating cable to piping with cable ties or fiberglass tape.
   d. C. Apply “Electric Traced” labels to the outside of the thermal insulation.

2. Tests:
   a. After installation and before and after installing the thermal insulation, subject heating cable to testing using a
b. **2500-Vdc Megger, Minimum insulation resistance shall be 20 megohms or greater.**

### 2.17 MECHANICAL SLEEVE SEALS

**A. Description:** Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. **Sealing Elements:** EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. **Pressure Plates:** Carbon steel. Include two for each sealing element.
3. **Connecting Bolts and Nuts:** Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.
4. **Basis of Design:** Pipeline Seal and Insulator, Inc. "Thunderline Link Seal."
5. **Manufacturers:**
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

### 2.18 SLEEVES

**A. Galvanized-Steel Sheet:** 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

**B. Steel Pipe:** ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

**C. Cast Iron:** Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

**D. Stack Sleeve Fittings:** Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing. Underdeck Clamp: Clamping ring with set screws.

**E. PVC Pipe:** ASTM D 1785, Schedule 40.

### 2.19 ESCUTCHEONS

**A. General:** Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

**B. One-Piece, Deep-Profile Type (walls and ceilings):** Deep-drawn, box-shaped brass with chrome-plated finish.

**C. One-Piece, Stamped-Steel Type (walls and ceilings):** With set screw or spring clips and chrome-plated finish.
D. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.20 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.


2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.


PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. 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 or, if conflicts exist, as indicated on Coordination Drawings.

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 to permit valve servicing.

G. Install piping at indicated and/or code-required slopes.

H. Install piping free of sags and bends.

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

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.
L. Install escutcheons for penetrations of walls, ceilings, and floors where exposed to view from any location in a finished space and in stairways, according to the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Other Piping: One-piece, stamped-steel type with spring clips.

2. Existing Piping: Same as for new piping.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other potentially-wet areas two inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
   a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two inches above finished floor level. Refer to Division 07, Section 076200, "Sheet Metal Flashing and Trim" for flashing.

3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

N. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for one inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

O. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07.

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
3.2 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve (unless valve construction facilitates disassembly) and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in piping systems.

3.3 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.4 HANGER AND SUPPORT APPLICATIONS

A. Comply with MSS SP-69 and 89 for pipe hanger selections and applications that are not specified otherwise in piping system Sections.

B. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

C. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

D. Use padded hangers for piping that is subject to scratching.

E. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 degrees F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes.
6. **Pipe Saddle Supports (MSS Type 36):** For support of pipes, NPS 4 and above, with steel pipe base stanchion support and cast-iron floor flange.

7. **Single Pipe Rolls (MSS Type 41):** For suspension of pipes, from 2 rods if longitudinal movement caused by expansion and contraction might occur.

8. **Complete Pipe Rolls (MSS Type 44):** For support of pipes, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

F. **Vertical-Piping Clamps:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Extension Pipe or Riser Clamps (MSS Type 8):** For support of pipe risers.

2. **Carbon- or Alloy-Steel Riser Clamps (MSS Type 42):** For support of pipe risers if longer ends are required for riser clamps.

G. **Building Attachments:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel or Malleable Concrete Inserts (MSS Type 18):** For upper attachment to suspend pipe hangers from concrete ceiling.

2. **Top-Beam C-Clamps (MSS Type 19):** For use under roof installations with bar-joist construction to attach to top flange of structural shape.

3. **Side-Beam or Channel Clamps (MSS Type 20):** For attaching to bottom flange of beams, channels, or angles.

4. **Center-Beam Clamps (MSS Type 21):** For attaching to center of bottom flange of beams.

5. **Welded Beam Attachments (MSS Type 22):** For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. **C-Clamps (MSS Type 23):** For structural shapes.

7. **Welded-Steel Brackets:** For support of pipes from below, or for suspending from above by using clip and rod.

8. **Side-Beam Brackets (MSS Type 34):** For sides of steel or wooden beams.

H. **Saddles and Shields:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Steel Pipe-Covering Protection Saddles (MSS Type 39):** To fill interior voids with insulation that matches adjoining insulation.

2. **Protection Shields (MSS Type 40):** Of length recommended in writing by manufacturer to prevent crushing insulation.

3. **Thermal-Hanger Shield Inserts:** For supporting insulated pipe.

I. **Spring Hangers and Supports:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. **Spring Cushions (MSS Type 48):** For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).

2. **Spring-Cushion Roll Hangers (MSS Type 49):** For equipping Type 41 roll hanger with springs.

3. **Variable-Spring Base Supports (MSS Type 52):** Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
J. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

K. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

L. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

M. Trapeze Pipe Hanger Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

N. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

O. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.


Q. Select and locate hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

R. Install lateral bracing with pipe hangers and supports to prevent swaying.

S. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

T. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

U. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

V. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
   b. NPS 4: 12 inches long and 0.06 inch thick.
   c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
   d. NPS 8 to 14: 24 inches long and 0.075 inch thick.

5. Insert Material: Length at least as long as protective shield.

6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09, Sections 099123, "Interior Painting" and 099113, "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.7 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

3.8 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.
SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

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 general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION
   A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
      1. Motor controllers.
      2. Torque, speed, and horsepower requirements of the load.
      3. Ratings and characteristics of supply circuit and required control sequence.
      4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
   A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
   B. Comply with NEMA MG 1 unless otherwise indicated.
   C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS
   A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F.

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513
SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC 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. Bronze angle valves.
   2. Brass ball valves.
   3. Bronze ball valves.
   4. Iron ball valves.
   5. Iron, single-flange butterfly valves.
   8. Bronze lift check valves.
  10. Iron swing check valves.
  11. Iron swing check valves with closure control.
  15. Bronze gate valves.
  17. Bronze globe valves.
  19. Lubricated plug valves.
  20. Eccentric plug valves.

B. Related Sections:
   1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
   2. Section 230550 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.
C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:

1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
   4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
   5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
   1. Gate Valves: With rising stem.
   2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Grooved: With grooves according to AWWA C606.
   4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Hammond Valve.
      b. Milwaukee Valve Company.
   2. Description:
a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig.
d. Ends: Threaded.
e. Stem and Disc: Bronze.
f. Packing: Asbestos free.
g. Handwheel: Malleable iron.

B. Class 125, Bronze Angle Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. NIBCO INC.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 150, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

D. Class 150, Bronze Angle Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Powell Valves.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.3 BRASS BALL VALVES

A. One-Piece, Reduced-Port, Brass Ball Valves with Brass Trim:

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

2. Description:
   b. CWP Rating: 400 psig
   c. Body Design: One piece.
   d. Body Material: Forged brass.
   e. Ends: Threaded.
   f. Seats: PTFE or TFE.
   g. Stem: Brass.
   h. Ball: Chrome-plated brass.
   i. Port: Reduced.

B. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. DynaQuip Controls.
   d. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
   e. Hammond Valve.
   f. Jamesbury; a subsidiary of Metso Automation.
g. Jomar International, LTD.

h. Kitz Corporation.

i. Legend Valve.

j. Marwin Valve; a division of Richards Industries.

k. Milwaukee Valve Company.

l. NIBCO INC.

m. Red-White Valve Corporation.

n. RuB Inc.

2. Description:


b. SWP Rating: 150 psig

c. CWP Rating: 600 psig

d. Body Design: Two piece.

e. Body Material: Forged brass.

f. Ends: Threaded.

g. Seats: PTFE or TFE.

h. Stem: Brass.

i. Ball: Chrome-plated brass.

j. Port: Full.

C. Two-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:

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

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.

d. Hammond Valve.

e. Jamesbury; a subsidiary of Metso Automation.

f. Kitz Corporation.

g. Marwin Valve; a division of Richards Industries.

h. Milwaukee Valve Company.

i. RuB Inc.

2. Description:


b. SWP Rating: 150 psig

c. CWP Rating: 600 psig Body Design: Two piece.

d. Body Material: Forged brass.

e. Ends: Threaded.

f. Seats: PTFE or TFE.

g. Stem: Stainless steel.

h. Ball: Stainless steel, vented.

i. Port: Full.

D. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond Valve.
   b. Jamesbury; a subsidiary of Metso Automation.
   c. Legend Valve.
   d. Marwin Valve; a division of Richards Industries.
   e. Milwaukee Valve Company.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Two piece.
   e. Body Material: Forged brass.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Brass.
   i. Ball: Chrome-plated brass.
   j. Port: Regular.

E. Two-Piece, Regular-Port, Brass Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Jamesbury; a subsidiary of Metso Automation.
   b. Marwin Valve; a division of Richards Industries.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Two piece.
   e. Body Material: Brass or bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Regular.

F. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Jomar International, LTD.
   b. Kitz Corporation.
   c. Red-White Valve Corporation.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Three piece.
   e. Body Material: Forged brass.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Brass.
   i. Ball: Chrome-plated brass.
   j. Port: Full.

G. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Jomar International, LTD.
   b. Kitz Corporation.
   c. Marwin Valve; a division of Richards Industries.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Three piece.
   e. Body Material: Forged brass.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.4 BRONZE BALL VALVES

A. One-Piece, Reduced-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. NIBCO INC.

2. Description:
b. CWP Rating: 400 psig
c. Body Design: One piece.
d. Body Material: Bronze.
e. Ends: Threaded.
f. Seats: PTFE or TFE.
g. Stem: Bronze.
h. Ball: Chrome-plated brass.
i. Port: Reduced.

B. One-Piece, Reduced-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. NIBCO INC.

2. Description:
   b. CWP Rating: 600 psig
   c. Body Design: One piece.
   d. Body Material: Bronze.
   e. Ends: Threaded.
   f. Seats: PTFE or TFE.
   g. Stem: Stainless steel.
   h. Ball: Stainless steel, vented.
   i. Port: Reduced.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Crane Valves.
   d. Hammond Valve.
   e. Lance Valves; a division of Advanced Thermal Systems, Inc.
   f. Legend Valve.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Red-White Valve Corporation.
   j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

D. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Hammond Valve.
   d. Lance Valves; a division of Advanced Thermal Systems, Inc.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

E. Two-Piece, Regular-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. DynaQuip Controls.
   f. Hammond Valve.
   g. Lance Valves; a division of Advanced Thermal Systems, Inc.
   h. Milwaukee Valve Company.
   i. NIBCO INC.

2. Description:
b. SWP Rating: 150 psig
c. CWP Rating: 600 psig
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Regular.

F. Two-Piece, Regular-Port, Bronze Ball Valves with Stainless-Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Hammond Valve.
   d. Milwaukee Valve Company.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Two piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Regular.

G. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   b. DynaQuip Controls.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Red-White Valve Corporation.

2. Description:
   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
d. Body Design: Three piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass.
j. Port: Full.

H. Three-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

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

   b. Hammond Valve.
   c. Milwaukee Valve Company.
   d. NIBCO INC.

2. Description:

   b. SWP Rating: 150 psig
   c. CWP Rating: 600 psig
   d. Body Design: Three piece.
   e. Body Material: Bronze.
   f. Ends: Threaded.
   g. Seats: PTFE or TFE.
   h. Stem: Stainless steel.
   i. Ball: Stainless steel, vented.
   j. Port: Full.

2.5 IRON BALL VALVES

A. Class 125, Iron Ball Valves:

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

   a. American Valve, Inc.
   b. Conbraco Industries, Inc.; Apollo Valves.
   c. Kitz Corporation.
   d. Sure Flow Equipment Inc.
   e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   b. CWP Rating: 200 psig
   d. Body Material: ASTM A 126, gray iron.
2.6 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Bray Controls; a division of Bray International.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
   e. Crane Co.; Crane Valve Group; Jenkins Valves.
   f. Crane Co.; Crane Valve Group; Stockham Division.
   g. DeZurik Water Controls.
   h. Hammond Valve.
   i. Kitz Corporation.
   j. Milwaukee Valve Company.
   k. NIBCO INC.
   l. Norriseal; a Dover Corporation company.
   m. Red-White Valve Corporation.
   n. Spence Strainers International; a division of CIRCOR International.
   o. Tyco Valves & Controls; a unit of Tyco Flow Control.
   p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

B. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Bray Controls; a division of Bray International.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
Spokane Transit Authority  
SCC Transit Center  
General Duty Valves for HVAC Piping

e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Hammond Valve.
i. Kitz Corporation.
j. Milwaukee Valve Company.
k. NIBCO INC.
l. Norriseal; a Dover Corporation company.
m. Red-White Valve Corporation.
n. Spence Strainers International; a division of CIRCOR International.
o. Tyco Valves & Controls; a unit of Tyco Flow Control.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: NBR.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Aluminum bronze.

C. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. Bray Controls; a division of Bray International.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
   e. Crane Co.; Crane Valve Group; Center Line.
   f. Crane Co.; Crane Valve Group; Stockham Division.
   g. DeZurik Water Controls.
   h. Hammond Valve.
   i. Kitz Corporation.
   j. Milwaukee Valve Company.
   k. Mueller Steam Specialty; a division of SPX Corporation.
   l. NIBCO INC.
   m. Norriseal; a Dover Corporation company.
   n. Spence Strainers International; a division of CIRCOR International.
   o. Sure Flow Equipment Inc.
   p. Tyco Valves & Controls; a unit of Tyco Flow Control.
   q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 150 psig
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Nickel-plated [or -coated] ductile iron.

D. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
      b. Bray Controls; a division of Bray International.
      c. Conbraco Industries, Inc.; Apollo Valves.
      d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
      e. Crane Co.; Crane Valve Group; Center Line.
      f. Crane Co.; Crane Valve Group; Stockham Division.
      g. DeZurik Water Controls.
      h. Hammond Valve.
      i. Kitz Corporation.
      j. Milwaukee Valve Company.
      k. Mueller Steam Specialty; a division of SPX Corporation.
      l. NIBCO INC.
      m. Norrisseal; a Dover Corporation company.
      n. Spence Strainers International; a division of CIRCOR International.
      o. Sure Flow Equipment Inc.
      p. Tyco Valves & Controls; a unit of Tyco Flow Control.
      q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

   2. Description:
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 150 psig
      c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
      d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
      e. Seat: NBR.
      f. Stem: One- or two-piece stainless steel.
      g. Disc: Nickel-plated [or -coated] ductile iron.

E. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
      b. Bray Controls; a division of Bray International.
      c. Conbraco Industries, Inc.; Apollo Valves.
      d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
      e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Hammond Valve.
i. Kitz Corporation.
j. Milwaukee Valve Company.
k. Mueller Steam Specialty; a division of SPX Corporation.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Sure Flow Equipment Inc.
q. Tyco Valves & Controls; a unit of Tyco Flow Control.
r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Stainless steel.

F. 150 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Hammond Valve.
i. Kitz Corporation.
j. Milwaukee Valve Company.
k. Mueller Steam Specialty; a division of SPX Corporation.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Sure Flow Equipment Inc.
q. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

2. Description:

a. Standard: MSS SP-67, Type I.
Spokane Transit Authority  
Section 230523  
SCC Transit Center  
General Duty Valves for HVAC Piping

b. CWP Rating: 150 psig  
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.  
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.  
e. Seat: NBR.  
f. Stem: One- or two-piece stainless steel.  
g. Disc: Stainless steel.

G. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.  
   b. Conbraco Industries, Inc.; Apollo Valves.  
   c. Cooper Cameron Valves; a division of Cooper Cameron Corp.  
   d. Crane Co.; Crane Valve Group; Jenkins Valves.  
   e. Crane Co.; Crane Valve Group; Stockham Division.  
   f. DeZurik Water Controls.  
   g. Flo Fab Inc.  
   h. Hammond Valve.  
   i. Kitz Corporation.  
   j. Legend Valve.  
   k. Milwaukee Valve Company.  
   l. NIBCO INC.  
   m. Norriseal; a Dover Corporation company.  
   n. Red-White Valve Corporation.  
   o. Spence Strainers International; a division of CIRCOR International.  
   p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-67, Type I.  
   b. CWP Rating: 200 psig  
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.  
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.  
   e. Seat: EPDM.  
   f. Stem: One- or two-piece stainless steel.  
   g. Disc: Aluminum bronze.

H. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Aluminum-Bronze Disc:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.  
   b. Conbraco Industries, Inc.; Apollo Valves.  
   c. Cooper Cameron Valves; a division of Cooper Cameron Corp.  
   d. Crane Co.; Crane Valve Group; Jenkins Valves.  
   e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Flo Fab Inc.
h. Hammond Valve.
i. Kitz Corporation.
j. Legend Valve.
k. Milwaukee Valve Company.
l. NIBCO INC.
m. Norriseal; a Dover Corporation company.
n. Red-White Valve Corporation.
o. Spence Strainers International; a division of CIRCOR International.
p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: NBR.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.

I. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Ductile-Iron Disc:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. American Valve, Inc.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Center Line.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Legend Valve.
l. Milwaukee Valve Company.
m. Mueller Steam Specialty; a division of SPX Corporation.
n. NIBCO INC.
o. Norriseal; a Dover Corporation company.
q. Sure Flow Equipment Inc.
r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 200 psig
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.

d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.

e. Seat: EPDM.

f. Stem: One- or two-piece stainless steel.

g. Disc: Nickel-plated [or -coated] ductile iron.

J. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Ductile-Iron Disc:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. American Valve, Inc.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
   e. Crane Co.; Crane Valve Group; Center Line.
   f. Crane Co.; Crane Valve Group; Stockham Division.
   g. DeZurik Water Controls.
   h. Flo Fab Inc.
   i. Hammond Valve.
   j. Kitz Corporation.
   k. Legend Valve.
   l. Milwaukee Valve Company.
   m. Mueller Steam Specialty; a division of SPX Corporation.
   n. NIBCO INC.
   o. Norriseal; a Dover Corporation company.
   q. Sure Flow Equipment Inc.
   r. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: NBR.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Nickel-plated [or -coated] ductile iron.

K. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Stainless-Steel Disc:

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

   a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
   b. American Valve, Inc.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
e. Crane Co.; Crane Valve Group; Jenkins Valves.
f. Crane Co.; Crane Valve Group; Stockham Division.
g. DeZurik Water Controls.
h. Flo Fab Inc.
i. Hammond Valve.
j. Kitz Corporation.
k. Legend Valve.
l. Milwaukee Valve Company.
m. Mueller Steam Specialty; a division of SPX Corporation.
n. NIBCO INC.
o. Norriseal; a Dover Corporation company.
q. Spence Strainers International; a division of CIRCOR International.
r. Sure Flow Equipment Inc.
s. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: EPDM.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Stainless steel.

L. 200 CWP, Iron, Single-Flange Butterfly Valves with NBR Seat and Stainless-Steel Disc:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
      b. American Valve, Inc.
      c. Conbraco Industries, Inc.; Apollo Valves.
      d. Cooper Cameron Valves; a division of Cooper Cameron Corp.
      e. Crane Co.; Crane Valve Group; Jenkins Valves.
      f. Crane Co.; Crane Valve Group; Stockham Division.
      g. DeZurik Water Controls.
      h. Flo Fab Inc.
      i. Hammond Valve.
      j. Kitz Corporation.
      k. Legend Valve.
      l. Milwaukee Valve Company.
      m. Mueller Steam Specialty; a division of SPX Corporation.
      n. NIBCO INC.
      o. Norriseal; a Dover Corporation company.
      q. Spence Strainers International; a division of CIRCOR International.
      r. Sure Flow Equipment Inc.
      s. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-67, Type I.
   b. CWP Rating: 200 psig
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
   e. Seat: NBR.
   f. Stem: One- or two-piece stainless steel.
   g. Disc: Stainless steel.

2.7 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Kennedy Valve; a division of McWane, Inc.
      b. Shurjoint Piping Products.
      c. Tyco Fire Products LP; Grinnell Mechanical Products.
      d. Victaulic Company.
   2. Description:
      a. Standard: MSS SP-67, Type I.
      b. CWP Rating: 175 psig
      c. Body Material: Coated, ductile iron.
      e. Disc: Coated, ductile iron.
      f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Anvil International, Inc.
      b. Kennedy Valve; a division of McWane, Inc.
      c. Mueller Steam Specialty; a division of SPX Corporation.
      d. NIBCO INC.
      e. Shurjoint Piping Products.
      f. Tyco Fire Products LP; Grinnell Mechanical Products.
      g. Victaulic Company.
   2. Description:
      a. Standard: MSS SP-67, Type I.
      b. NPS 8 and Smaller CWP Rating: 300 psig
      c. NPS 10 and Larger CWP Rating: 200 psig
d. Body Material: Coated, ductile iron.

e. Stem: Two-piece stainless steel.

f. Disc: Coated, ductile iron.

g. Seal: EPDM.

2.8 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Flowseal.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Jamesbury; a subsidiary of Metso Automation.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Process Development & Control, Inc.
l. Tyco Valves & Controls; a unit of Tyco Flow Control.
m. Xomox Corporation.

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 285 psig at 100 deg F
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:

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

a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
b. Bray Controls; a division of Bray International.
c. Cooper Cameron Valves; a division of Cooper Cameron Corp.
d. Crane Co.; Crane Valve Group; Flowseal.
e. Crane Co.; Crane Valve Group; Stockham Division.
f. DeZurik Water Controls.
g. Hammond Valve.
h. Jamesbury; a subsidiary of Metso Automation.
i. Milwaukee Valve Company.
j. NIBCO INC.
k. Process Development & Control, Inc.
l. Tyco Valves & Controls; a unit of Tyco Flow Control.
m. Xomox Corporation.

2. Description:

a. Standard: MSS SP-68.
b. CWP Rating: 720 psig at 100 deg F
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: Carbon steel, cast iron, or ductile iron.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.9 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Lift Check Valves with Nonmetallic Disc:

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

a. Flo Fab Inc.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. Mueller Steam Specialty; a division of SPX Corporation.
f. NIBCO INC.
2. Description:

a. Standard: MSS SP-80, Type 2.

b. CWP Rating: 200 psig


e. Ends: Threaded.

f. Disc: NBR, PTFE, or TFE.

2.10 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

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

a. American Valve, Inc.

b. Crane Co.; Crane Valve Group; Crane Valves.

c. Crane Co.; Crane Valve Group; Jenkins Valves.

d. Crane Co.; Crane Valve Group; Stockham Division.

e. Hammond Valve.

f. Kitz Corporation.

g. Milwaukee Valve Company.

h. NIBCO INC.

i. Powell Valves.

j. Red-White Valve Corporation.

k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

l. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 3.

b. CWP Rating: 200 psig

c. Body Design: Horizontal flow.


e. Ends: Threaded.

f. Disc: Bronze.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

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

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Division.

d. Hammond Valve.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
j. <Insert manufacturer's name>.

2. Description:
   
a. Standard: MSS SP-80, Type 4.
b. CWP Rating: 200 psig
c. Body Design: Horizontal flow.
e. Ends: Threaded.
f. Disc: PTFE or TFE.

C. Class 150, Bronze Swing Check Valves with Bronze Disc:

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

   a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Red-White Valve Corporation.
i. Zy-Tech Global Industries, Inc.

2. Description:

   a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig
c. Body Design: Horizontal flow.
e. Ends: Threaded.
f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:

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

   a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 300 psig
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.

2.11 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. Crane Co.; Crane Valve Group; Stockham Division.
      d. Hammond Valve.
      e. Kitz Corporation.
      f. Legend Valve.
      g. Milwaukee Valve Company.
      h. NIBCO INC.
      i. Powell Valves.
      j. Red-White Valve Corporation.
      k. Sure Flow Equipment Inc.
      l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
      m. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig
   c. NPS 14 to NPS 24, CWP Rating: 150 psig
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:
a. Standard: MSS SP-71, Type I.
b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
c. NPS 14 to NPS 24 CWP Rating: 150 psig
d. Body Design: Clear or full waterway.
e. Body Material: ASTM A 126, gray iron with bolted bonnet.
f. Ends: Flanged.
g. Trim: Composition.
h. Seat Ring: Bronze.
i. Disc Holder: Bronze.
j. Disc: PTFE or TFE.
k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

2.12 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:

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

   a. NIBCO INC.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
d. Body Design: Clear or full waterway.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.

f. Ends: Flanged.

g. Trim: Bronze.

h. Gasket: Asbestos free.

i. Closure Control: Factory-installed, exterior lever and spring.

B. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:

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

a. Crane Co.; Crane Valve Group; Crane Valves.

b. Crane Co.; Crane Valve Group; Jenkins Valves.

c. Crane Co.; Crane Valve Group; Stockham Division.

d. Hammond Valve.

e. Milwaukee Valve Company.

f. NIBCO INC.

g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-71, Type I.

b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig

c. NPS 14 to NPS 24 CWP Rating: 150 psig

d. Body Design: Clear or full waterway.

e. Body Material: ASTM A 126, gray iron with bolted bonnet.

f. Ends: Flanged.

g. Trim: Bronze.

h. Gasket: Asbestos free.

i. Closure Control: Factory-installed, exterior lever and weight.

2.13 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:

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

a. Anvil International, Inc.

b. Shurjoint Piping Products.

c. Tyco Fire Products LP; Grinnell Mechanical Products.

d. Victaulic Company.

2. Description:

a. CWP Rating: 300 psig


c. Seal: EPDM.

d. Disc: Spring operated, ductile iron or stainless steel.
2.14 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

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

   a. Anvil International, Inc.
   b. APCO Willamette Valve and Primer Corporation.
   c. Crispin Valve.
   d. DFT Inc.
   e. Flo Fab Inc.
   f. GA Industries, Inc.
   g. Hammond Valve.
   h. Metraflex, Inc.
   i. Milwaukee Valve Company.
   j. Mueller Steam Specialty; a division of SPX Corporation.
   k. NIBCO INC.
   l. Spence Strainers International; a division of CIRCOR International.
   m. Sure Flow Equipment Inc.
   n. Val-Matic Valve & Manufacturing Corp.
   o. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Compact wafer.
   f. Seat: Bronze.

B. Class 125, Iron, Globe, Center-Guided Check Valves with Metal Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Flomatic Corporation.
   e. Hammond Valve.
   f. Metraflex, Inc.
   g. Milwaukee Valve Company.
   h. Mueller Steam Specialty; a division of SPX Corporation.
   i. NIBCO INC.
   j. Spence Strainers International; a division of CIRCOR International.
   k. Sure Flow Equipment Inc.
   l. Val-Matic Valve & Manufacturing Corp.
   m. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

C. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 300 psig
   c. NPS 14 to NPS 24 CWP Rating: 250 psig
   e. Style: Compact wafer.
   f. Seat: Bronze.

D. Class 150, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 300 psig
   c. NPS 14 to NPS 24 CWP Rating: 250 psig
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

E. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. **Description:**
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Compact wafer, spring loaded.
   f. Seat: Bronze.

F. **Class 250, Iron, Globe, Center-Guided Check Valves with Metal Seat:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Flo Fab Inc.
   e. Hammond Valve.
   f. Metraflex, Inc.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Sure Flow Equipment Inc.
   j. Val-Matic Valve & Manufacturing Corp.

2. **Description:**
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: Bronze.

G. **Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:**

1. **Manufacturers:** Subject to compliance with requirements, provide products by one of the following:
2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 400 psig
   e. Style: Compact wafer, spring loaded.
   f. Seat: Bronze.

H. Class 300, Iron, Globe, Center-Guided Check Valves with Metal Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.
   2. Description:
      b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
      c. NPS 14 to NPS 24 CWP Rating: 400 psig
      e. Style: Globe, spring loaded.
      f. Ends: Flanged.
      g. Seat: Bronze.

I. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. DFT Inc.
      d. Flo Fab Inc.
      e. Hammond Valve.
      f. Milwaukee Valve Company.
      g. NIBCO INC.
      h. Spence Strainers International; a division of CIRCOR International.
      i. Sure Flow Equipment Inc.
      j. Val-Matic Valve & Manufacturing Corp.
   2. Description:
b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig

c. NPS 14 to NPS 24 CWP Rating: 150 psig

d. Body Material: ASTM A 126, gray iron.

e. Style: Compact wafer.

f. Seat: EPDM

J. Class 125, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

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

   a. Anvil International, Inc.
   
b. APCO Willamette Valve and Primer Corporation.
   
c. Crispin Valve.
   
d. DFT Inc.
   
e. GA Industries, Inc.
   
f. Hammond Valve.
   
g. Milwaukee Valve Company.
   
h. NIBCO INC.
   
i. Sure Flow Equipment Inc.
   
j. Val-Matic Valve & Manufacturing Corp.

2. Description:

   
b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   
c. NPS 14 to NPS 24 CWP Rating: 150 psig
   
d. Body Material: ASTM A 126, gray iron.
   
e. Style: Globe, spring loaded.
   
f. Ends: Flanged.
   
g. Seat: EPDM

K. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   
b. Crispin Valve.
   
c. Val-Matic Valve & Manufacturing Corp.

2. Description:

   
b. NPS 2-1/2 to NPS 12 CWP Rating: 300 psig
   
c. NPS 14 to NPS 24 CWP Rating: 250 psig
   
   
e. Style: Compact wafer.
   
f. Seat: EPDM

L. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 300 psig
   c. NPS 14 to NPS 24 CWP Rating: 250 psig
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: EPDM

M. Class 250, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Flo Fab Inc.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Sure Flow Equipment Inc.
   i. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Compact wafer, spring loaded.
   f. Seat: EPDM

N. Class 250, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crispin Valve.
   c. DFT Inc.
   d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 126, gray iron.
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: EPDM

O. Class 300, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 400 psig
   e. Style: Compact wafer, spring loaded.
   f. Seat: EPDM

P. Class 300, Iron, Globe, Center-Guided Check Valves with Resilient Seat:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. APCO Willamette Valve and Primer Corporation.
      b. Crispin Valve.
      c. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 400 psig
   e. Style: Globe, spring loaded.
   f. Ends: Flanged.
   g. Seat: EPDM
2.15 IRON, PLATE-TYPE CHECK VALVES

A. Class 125, Iron, Dual-Plate Check Valves with Metal Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Flomatic Corporation.
   d. Mueller Steam Specialty; a division of SPX Corporation.

2. Description:

   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   e. Body Material: ASTM A 126, gray iron.
   f. Seat: Bronze.

B. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Mueller Steam Specialty; a division of SPX Corporation.
   d. Val-Matic Valve & Manufacturing Corp.

2. Description:

   b. NPS 2-1/2 to NPS 12 CWP Rating: 300 psig
   c. NPS 14 to NPS 24 CWP Rating: 250 psig
   e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
   f. Seat: Bronze.

C. Class 250, Iron, Dual-Plate Check Valves with Metal Seat:

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

   a. APCO Willamette Valve and Primer Corporation.
   b. Crane Co.; Crane Valve Group; Crane Valves.

2. Description:

b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig  
c. NPS 14 to NPS 24 CWP Rating: 300 psig  
e. Body Material: ASTM A 126, gray iron.  
f. Seat: Bronze.

d. Class 300, Iron, Dual-Plate Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. APCO Willamette Valve and Primer Corporation.  
b. Crane Co.; Crane Valve Group; Crane Valves.  
c. Mueller Steam Specialty; a division of SPX Corporation.  
d. Val-Matic Valve & Manufacturing Corp.

2. Description:
   
b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig  
c. NPS 14 to NPS 24 CWP Rating: 400 psig  
e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.  
f. Seat: Bronze.

e. Class 125, Iron, Single-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. Flo Fab Inc.  
b. Sure Flow Equipment Inc.

2. Description:
   
b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig  
c. NPS 14 to NPS 24 CWP Rating: 150 psig  
d. Body Design: Wafer, spring-loaded plate.  
e. Body Material: ASTM A 126, gray iron.  
f. Seat: EPDM

F. Class 125, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   
a. APCO Willamette Valve and Primer Corporation.  
b. Cooper Cameron Valves TVB Techno.  
c. Crane Co.; Crane Valve Group; Crane Valves.  
d. Crane Co.; Crane Valve Group; Stockham Division.
e. NIBCO INC.
f. Spence Strainers International; a division of CIRCOR International.
g. Sure Flow Equipment Inc.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   e. Body Material: ASTM A 126, gray iron.
   f. Seat: EPDM

G. Class 150, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 300 psig
   c. NPS 14 to NPS 24 CWP Rating: 250 psig
   e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
   f. Seat: EPDM

H. Class 250, Iron, Wafer, Single-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sure Flow Equipment Inc.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Design: Wafer, spring-loaded plate.
   e. Body Material: ASTM A 126, gray iron.
   f. Seat: EPDM

I. Class 250, Iron, Dual-Plate Check Valves with Resilient Seat:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Sure Flow Equipment Inc.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   e. Body Material: ASTM A 126, gray iron.
   f. Seat: EPDM

J. Class 300, Iron, Dual-Plate Check Valves with Resilient Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. APCO Willamette Valve and Primer Corporation.
   b. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 400 psig
   e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
   f. Seat: EPDM

2.16 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Hammond Valve.
   f. Kitz Corporation.
   g. Milwaukee Valve Company.
   h. NIBCO INC.
   i. Powell Valves.
   j. Red-White Valve Corporation.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
l. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 200 psig
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

B. Class 125, RS Bronze Gate Valves:

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

a. American Valve, Inc.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Crane Co.; Crane Valve Group; Jenkins Valves.
d. Crane Co.; Crane Valve Group; Stockham Division.
e. Hammond Valve.
f. Kitz Corporation.
g. Milwaukee Valve Company.
h. NIBCO INC.
i. Powell Valves.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
k. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig
d. Ends: Threaded
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

C. Class 150, NRS Bronze Gate Valves:

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

a. Hammond Valve.
b. Kitz Corporation.
c. Milwaukee Valve Company.
d. NIBCO INC.
e. Powell Valves.
f. Red-White Valve Corporation.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

D. Class 150, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Hammond Valve.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   i. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.17 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Flo Fab Inc.
e. Hammond Valve.
f. Kitz Corporation.
g. Legend Valve.
h. Milwaukee Valve Company.
i. NIBCO INC.
j. Powell Valves.
k. Red-White Valve Corporation.
l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
m. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

B. Class 125, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Flo Fab Inc.
   e. Hammond Valve.
   f. Kitz Corporation.
   g. Legend Valve.
   h. Milwaukee Valve Company.
   i. NIBCO INC.
   j. Powell Valves.
   k. Red-White Valve Corporation.
   l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   m. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Class 250, NRS, Iron Gate Valves:

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

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. NIBCO INC.

2. Description:

   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:

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

   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Hammond Valve.
   d. Milwaukee Valve Company.
   e. NIBCO INC.
   f. Powell Valves.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 500 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

2.18 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. Hammond Valve.
   d. Kitz Corporation.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Powell Valves.
   h. Red-White Valve Corporation.
   i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   j. Zy-Tech Global Industries, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig
   d. Ends: Threaded
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

B. Class 125, Bronze Globe Valves with Nonmetallic Disc:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
      b. Crane Co.; Crane Valve Group; Stockham Division.
      c. NIBCO INC.
      d. Red-White Valve Corporation.

   2. Description:
      a. Standard: MSS SP-80, Type 2.
      b. CWP Rating: 200 psig (1380 kPa).
      d. Ends: Threaded
      e. Stem: Bronze.
      f. Disc: PTFE or TFE.
      g. Packing: Asbestos free.
      h. Handwheel: Malleable iron.

C. Class 150, Bronze Globe Valves with Nonmetallic Disc:

   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Crane Co.; Crane Valve Group; Crane Valves.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Powell Valves.
g. Red-White Valve Corporation.
h. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
i. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.19 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

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

a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. Hammond Valve.
e. Kitz Corporation.
f. Milwaukee Valve Company.
g. NIBCO INC.
h. Powell Valves.
i. Red-White Valve Corporation.
j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
k. Zy-Tech Global Industries, Inc.

2. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 200 psig
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.

B. Class 250, Iron Globe Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Jenkins Valves.
   c. Crane Co.; Crane Valve Group; Stockham Division.
   d. Hammond Valve.
   e. Milwaukee Valve Company.
   f. NIBCO INC.
   g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 500 psig
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

2.20 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

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

2. Description:
   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular or short
   f. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:

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

2. Description:
   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
c. NPS 14 to NPS 24 CWP Rating: 150 psig
d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short
Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular or short.
   f. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 200 psig
   c. NPS 14 to NPS 24 CWP Rating: 150 psig
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular or short
   f. Plug: Cast iron or bronze with sealant groove.

E. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:

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

2. Description:
a. Standard: MSS SP-78, Type II.
b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
c. NPS 14 to NPS 24 CWP Rating: 300 psig
d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
e. Pattern: Regular or short
f. Plug: Cast iron or bronze with sealant groove.

F. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:

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

2. Description:
   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular or short
   f. Plug: Cast iron or bronze with sealant groove.

G. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems; a unit of Robbins & Myers, Inc.

2. Description:
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular or short
   f. Plug: Cast iron or bronze with sealant groove.

H. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
c. R & M Energy Systems, a unit of Robbins & Myers, Inc.

2. Description:
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12 CWP Rating: 400 psig
   c. NPS 14 to NPS 24 CWP Rating: 300 psig
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
   e. Pattern: Regular or short
   f. Plug: Cast iron or bronze with sealant groove.

2.21 ECCENTRIC PLUG VALVES

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Clow Valve Co.; a division of McWane, Inc.
   b. DeZurik Water Controls.
   c. Homestead Valve; a division of Olson Technologies, Inc.
   d. M&H Valve Company; a division of McWane, Inc.
   e. Milliken Valve Company.
   f. Henry Pratt Company.
   g. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. CWP Rating: 175 psig minimum.
   c. Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
   d. Bearings: Oil-impregnated bronze or stainless steel.
   e. Ends: Flanged.
   f. Stem-Seal Packing: Asbestos free.
   g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

2.22 CHAINWHEELS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Babbitt Steam Specialty Co.
   2. Roto Hammer Industries.
   3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.
1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball valve stems.
3. Sprocket Rim with Chain Guides: Ductile or cast iron, of type and size required for valve. Retain only first option in subparagraph below unless another material is required.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install chainwheels on operators for ball valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.

F. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Center-Guided Check Valves: In horizontal or vertical position, between flanges.
   3. Lift Check Valves: With stem upright and plumb.
3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball, butterfly valves.
3. Throttling Service except Steam: Globe or angle valves.
4. Throttling Service, Steam: Globe or angle valves.
5. Pump-Discharge Check Valves:
   a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
   b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 and Larger: Flanged ends.
7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze [and Brass] Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125, bronze nonmetallic disc.
3. Ball Valves: One-piece, full port, brass with brass trim.
4. Bronze Swing Check Valves: Class 125 disc.
5. Bronze Gate Valves: Class 125, bronze.

B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
5. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
6. High-Performance Butterfly Valves: Class 150, single flange.
7. Iron Swing Check Valves: Class 125 seats.
8. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
9. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
10. Iron, Center-Guided Check Valves: Class 125 seat.
11. Iron, Plate-Type Check Valves: Class 125 seat.
12. Iron Gate Valves: Class 125.
15. Eccentric Plug Valves: 175 CWP, resilient seating.

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze [and Brass] Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 125, disc.
3. Ball Valves: One-piece, full port, brass with brass trim.
4. Bronze Swing Check Valves: Class 125, disc.
5. Bronze Gate Valves: Class 125.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
5. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
6. High-Performance Butterfly Valves: Class 150, single flange.
7. Iron Swing Check Valves: Class 125 seats.
8. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
9. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
10. Iron, Center-Guided Check Valves, NPS 2-1/2 to NPS 24: Class 125 seat.
11. Iron, Plate-Type Check Valves: Class 125 seat.
12. Iron Gate Valves: Class 125.

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze Angle Valves: Class 125, bronze disc.
   3. Ball Valves: One-piece, full port, brass with brass trim.
   4. Bronze Swing Check Valves: Class 125, bronze disc.
   5. Bronze Gate Valves: Class 125, NRS.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
   5. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12: 175 CWP.
   6. High-Performance Butterfly Valves: Class 150, single flange.
   7. Iron Swing Check Valves: Class 125 seats.
   8. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
   9. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
  10. Iron, Center-Guided Check Valves: Class 125 seat.
  11. Iron, Plate-Type Check Valves: Class 125 seat.
  12. Iron Gate Valves: Class 125.

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG OR LESS)

A. Pipe NPS 2 and Smaller:
   1. Bronze Angle Valves: Class 125, bronze disc.
   2. Ball Valves: One-piece, full port, brass with brass trim.
   3. Bronze Swing Check Valves: Class 125, bronze disc.
   4. Bronze Gate Valves: Class 125, NRS.
   5. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
3. High-Performance Butterfly Valves: Class 150, single flange.
4. Iron Swing Check Valves: Class 125 seats.
5. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
6. Iron Gate Valves: Class 125.

3.9 HIGH-PRESSURE STEAM VALVE SCHEDULE (MORE THAN 15 PSIG)

A. Pipe NPS 2 and Smaller:
   1. Bronze Angle Valves: Class 125, bronze disc.
   2. Ball Valves: One-piece, full port, brass with brass trim.
   3. Bronze Swing Check Valves: Class 125, bronze disc.
   4. Bronze Gate Valves: Class 125, NRS, bronze.
   5. Globe Valves: Class 125, bronze, bronze disc.

B. Pipe Sizes NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Ball Valves, NPS 2-1/2 to NPS 10: Class 150, iron.
   3. High-Performance Butterfly Valves: Class 150, single flange.
   4. Iron Swing Check Valves: Class 125 seats.
   5. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
   6. Iron Gate Valves: Class 125.

3.10 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Angle Valves: Class 125, bronze disc.
   2. Ball Valves: One-piece, full port, brass with brass trim.
   3. Bronze Swing Check Valves: Class 125, bronze disc.
   4. Bronze Gate Valves: Class 125, NRS.
   5. Bronze Globe Valves: Class 125, bronze disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
   3. High-Performance Butterfly Valves: Class 150, single flange.
   4. Iron Swing Check Valves: Class 125 seats.
   5. Iron Swing Check Valves with Closure Control: Class 125, lever and spring.
   6. Iron Gate Valves: Class 125.
8. Lubricated Plug Valves: Class 125, regular gland.

END OF SECTION 230523
SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following hangers and supports for HVAC system piping and equipment:

1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment supports.

B. Related Sections include the following:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
5. Section 233100 “Metal Ducts and Casings " for duct hangers and supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."
1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment.

1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Fiberglass pipe hangers.
   3. Thermal-hanger shield inserts.
   4. Powder-actuated fastener systems.

B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Fiberglass strut systems. Include Product Data for components.
   4. Pipe stands. Include Product Data for components.
   5. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
   5. ASME Boiler and Pressure Vessel Code: Section IX.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Bergen-Power Pipe Supports.
4. Carpenter & Paterson, Inc.
5. Empire Industries, Inc.
6. ERICO/Michigan Hanger Co.
7. Globe Pipe Hanger Products, Inc.
8. Grinnell Corp.
9. GS Metals Corp.
11. PHD Manufacturing, Inc.
12. PHS Industries, Inc.
13. Piping Technology & Products, Inc.
14. Tolco Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.
2.4 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers: Similar to MSS Type 1, steel pipe hanger except hanger is made of fiberglass and continuous-thread rod and nuts are made of polyurethane or stainless steel.

1. Manufacturers:
   b. Champion Fiberglass, Inc.
   d. Seaside, Inc.
   e. Unistrut Corp.; Tyco International, Ltd.
   f. Wesanco, Inc.

B. Strap-Type, Fiberglass Pipe Hangers: Made of fiberglass loop with stainless-steel continuous-thread rod, nuts, and support hook.

1. Manufacturers:
   a. Plasti-Fab, Inc.

2.5 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Manufacturers:

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Toleo Inc.
7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.6 FIBERGLASS STRUT SYSTEMS

A. Description: Shop- or field-fabricated pipe-support assembly, similar to MFMA-3, made of fiberglass channels and other components.

B. Manufacturers:

2. Champion Fiberglass, Inc.
2.7 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:
   1. Carpenter & Paterson, Inc.
   2. ERICO/Michigan Hanger Co.
   3. PHS Industries, Inc.
   4. Pipe Shields, Inc.
   5. Rilco Manufacturing Company, Inc.
   6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.8 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

   1. Manufacturers:
      a. Hilti, Inc.
      b. ITW Ramset/Red Head.
      c. Masterset Fastening Systems, Inc.
      d. MKT Fastening, LLC.
      e. Powers Fasteners.

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

   1. Manufacturers:
2.9 PIPE STAND FABRICATION

A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

1. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.

C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:
   a. MIRO Industries.

D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Manufacturers:
   a. ERICO/Michigan Hanger Co.
   b. MIRO Industries.
   c. Portable Pipe Hangers.

3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:
   a. Portable Pipe Hangers.

2. Bases: One or more plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.10 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

2.11 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. **Steel Turnbuckles (MSS Type 13):** For adjustment up to 6 inches for heavy loads.
2. **Steel Clevises (MSS Type 14):** For 120 to 450 deg F piping installations.
3. **Swivel Turnbuckles (MSS Type 15):** For use with MSS Type 11, split pipe rings.
4. **Malleable-Iron Sockets (MSS Type 16):** For attaching hanger rods to various types of building attachments.
5. **Steel Weldless Eye Nuts (MSS Type 17):** For 120 to 450 deg F piping installations.

1. **Building Attachments:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. **Steel or Malleable Concrete Inserts (MSS Type 18):** For upper attachment to suspend pipe hangers from concrete ceiling.
   2. **Top-Beam C-Clamps (MSS Type 19):** For use under roof installations with bar-joist construction to attach to top flange of structural shape.
   3. **Side-Beam or Channel Clamps (MSS Type 20):** For attaching to bottom flange of beams, channels, or angles.
   4. **Center-Beam Clamps (MSS Type 21):** For attaching to center of bottom flange of beams.
   5. **Welded Beam Attachments (MSS Type 22):** For attaching to bottom of beams if loads are considerable and rod sizes are large.
   6. **C-Clamps (MSS Type 23):** For structural shapes.
   7. **Top-Beam Clamps (MSS Type 25):** For top of beams if hanger rod is required tangent to flange edge.
   8. **Side-Beam Clamps (MSS Type 27):** For bottom of steel I-beams.
   9. **Steel-Beam Clamps with Eye Nuts (MSS Type 28):** For attaching to bottom of steel I-beams for heavy loads.
   10. **Linked-Steel Clamps with Eye Nuts (MSS Type 29):** For attaching to bottom of steel I-beams for heavy loads, with link extensions.
   11. **Malleable Beam Clamps with Extension Pieces (MSS Type 30):** For attaching to structural steel.
   12. **Welded-Steel Brackets:** For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
       
       a. **Light (MSS Type 31):** 750 lb.
       b. **Medium (MSS Type 32):** 1500 lb.
       c. **Heavy (MSS Type 33):** 3000 lb.

   13. **Side-Beam Brackets (MSS Type 34):** For sides of steel or wooden beams.
   14. **Plate Lugs (MSS Type 57):** For attaching to steel beams if flexibility at beam is required.
   15. **Horizontal Travelers (MSS Type 58):** For supporting piping systems subject to linear horizontal movement where headroom is limited.

1. **Saddles and Shields:** Unless otherwise indicated and except as specified in piping system Sections, install the following types:

   1. **Steel Pipe-Covering Protection Saddles (MSS Type 39):** To fill interior voids with insulation that matches adjoining insulation.
   2. **Protection Shields (MSS Type 40):** Of length recommended in writing by manufacturer to prevent crushing insulation.
   3. **Thermal-Hanger Shield Inserts:** For supporting insulated pipe.
K. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.

F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

G. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:
   1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
   2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Section 077200 "Roof Accessories" for curbs.

I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.


K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

L. Install lateral bracing with pipe hangers and supports to prevent swaying.

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

N. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
      e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
   5. Pipes NPS 8 and Larger: Include wood inserts.
   6. Insert Material: Length at least as long as protective shield.
   7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.
3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 230529
SECTION 230540 - VIBRATION AND SEISMIC CONTROLS 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 EXTENT OF VIBRATION CONTROL WORK

A. Vibration Isolation: All equipment and piping as noted on the equipment, ductwork and piping schedules in Part 3 of the specification shall be provided with vibration isolators to prevent the transmission of vibration and transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

B. Pipe Riser Resilient Supports: Provide resilient support for all risers subject to significant expansion and/or contraction.

1.3 EXTENT OF SEISMIC CONTROL WORK

A. Seismic Restraints for New Construction: Provide professional structural engineering for seismic control of all new and relocated equipment, ductwork and piping specified in Division 23. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards.

B. Seismic Restraints for Remodeled Areas: Provide professional structural engineering for seismic control of all existing equipment, ductwork and piping that is normally provided under Division 23 and that will remain in place in areas where new ceilings are being provided as part of this project. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards.

C. Existing Construction: Provide professional structural engineering for seismic control of the existing equipment, ductwork and piping listed below that is not located within the remodeled areas. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards.

D. Omission of restraints for small components: Restraints may be omitted for smaller equipment, ductwork and piping only where specifically allowed by Code and referenced Standards, and where specifically allowed by the Qualified Professional Engineer (QPE) specified below. Restraints may only be omitted after the QPE has determined that adequate flexibility will be provided between restrained and non-restrained connected elements and determined that movement of unrestrained elements will not cause damage to adjacent elements.
1.4 DEFINITIONS


B. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.5 SEISMIC CONTROLS ENGINEERING REQUIREMENTS

A. Qualified Professional Engineer: Contractor shall provide the services of a qualified professional structural engineer to engineer, design and/or select anchorage methods for all equipment, ductwork and piping specified in this Division of the Specifications. This requirement applies to equipment, ductwork and piping that is supported from above or below and that is supported with vibration isolation or not.

1. A qualified professional engineer (QPE) familiar with all of the applicable codes and design standards related to seismic protection of HVAC ductwork, piping and equipment and qualified in structural design of seismic protections and their interaction with building structures shall be responsible for execution of the work herein. Where applicable, the QPE shall also analyze wind forces and shall utilize these forces (if greater than seismic forces) when designing component anchorages. The tasks of the QPE are as follows:

a. Shall be responsible for the preparation of drawings, analysis, specifications, and inspection of the seismic protections required by Code and referenced Standards.

b. Shall coordinate with the Structural Engineer of Record of the building structure for the proper establishment of seismic values, applicable codes, and other requirements of the project related to seismic and wind design.

c. Shall verify the applicability of all codes and design standards with the Authority Having Jurisdiction and shall coordinate with the Authority where codes conflict or are open for interpretation for variances and clarifications.

d. Shall inform the Contractor where special provisions in other work, such as routine hanger hardware selection, are required to accommodate seismic restraint. Changes from specified hanger hardware will require A/E prior approval and shall be provided without change in Contract cost.

e. Shall analyze specified and/or Contractor-proposed ductwork and piping materials along with associated joining methods for seismic-related strength (flexibility and/or “toughness”) and determine bracing spacing that will maintain appropriate integrity of the ductwork and piping during and after a design seismic event. If changes in construction are recommended in order to minimize the frequency of bracing, these shall be submitted for A/E review and will only be considered if a significant cost credit is offered.

f. Shall analyze specified and/or Contractor-proposed ductwork and piping materials along with associated joining methods for flexibility and determine the appropriate point bracing should stop along a specific run (when importance factor changes or when size reduces to a point where bracing may not be required).

g. Shall acquire equipment certifications for seismic worthiness from all equipment manufacturers where required by applicable codes or these specifications. These certifications shall be included in a final report to the Owner.

h. Shall perform calculations and select all required anchors and restraints.
1. Shall develop drawings (bearing QPE seal) of seismic controls that document the seismic anchors and restraints, their layout and the details for their installation. Where design standards apply, the drawings shall note the locations and identify the standard details that apply.

2. The QPE shall be licensed to provide structural engineering in the project state.

B. Seismic-Restraint Loading: Engineering, selection and placement of seismic restraints shall be determined by the QPE after reviewing the project with the Structural Engineer of Record (for the building structure). Obtain all needed parameters directly from that engineer and clearly document these parameters within the submittals.

C. Components with Importance Factor Ip=1.5: Engineering, selection and placement of seismic restraints shall be determined by the QPE based on the following components having an Importance Factor of Ip=1.5:

1. Fuel source equipment and all sizes of piping.
2. Steam and condensate equipment and piping of all sizes.
3. All sizes of piping located in Electrical Rooms, Mechanical Rooms, Generator Rooms and Refrigeration Rooms. This applies to all kinds of piping, whether connected to equipment in those rooms or not.
4. Heating water equipment and piping greater than 2” size. Piping 2” in size and less that does not have a readily-accessible isolation valve separating it from any piping greater than 2” size.
5. Chilled water equipment and piping greater than 2” size. Piping 2” in size and less that does not have a readily-accessible isolation valve separating it from any piping greater than 2” size.
6. All supply air equipment and ductwork upstream of terminal units.
7. Supply terminal units.
8. Supply ductwork downstream of terminal units greater than 3 square feet in area.
9. Isolation room exhaust equipment and ductwork of all sizes.
10. Return and exhaust equipment and ductwork greater than 3 square feet in area.
11. All other components required by Code to have an importance factor of Ip=1.5.

D. Components with Importance Factor Ip=1.0: All components not identified above as having an Importance Factor of Ip=1.5:

1.6 RELATED WORK

A. Seismic Anchorage for Housekeeping Pads:

1. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be provided as part of this work, if not already adequate as indicated in the documents of other Divisions. This requirement applies only to pads that receive seismic forces for equipment anchored under this Section.

2. Housekeeping pads shall be coordinated by the seismic controls engineer to result in sizing such that a minimum edge distance of ten (10) bolt diameters is provided all around the outermost anchor bolts to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.
3. Provide restraint attachment plates cast into housekeeping pads, concrete inserts, double-sided beam clamps, etc., in accordance with the requirements of the manufacturer's calculations.

1.7 VIBRATION ISOLATION AND RISER SUPPORT SUBMITTALS

A. Product Data: For the following:

1. Vibration Isolators: Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Construction Details and Calculations:

1. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
2. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

C. Operation and Maintenance Data.

1.8 SEISMIC CONTROL SUBMITTALS

A. Product Data: Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

1. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
2. Annotate to indicate application of each product submitted and compliance with requirements.

B. Construction Details and Calculations: For seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
2. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and
spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Layout Drawings: Show coordination of seismic bracing for ductwork, piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints. Plans shall utilize copies of the contractor’s coordination plans and shall show all locations and types for the following. The registered professional engineer must stamp plans.

1. All seismic brace locations.
2. All anchorage connections to the structure. Quantity and size
3. Brace reactions at all connection points to the structure, for Structural Engineer of Record use in checking suitability of the building structure.
4. Total vertical load at seismic brace locations.
5. Type and size of brace member.
6. Suspended utility max lbs per lineal foot or max pipe size at all seismic locations.
7. Minimum rod size at all seismic locations.
8. Vertical support anchors at non-seismic and seismic locations.
9. Horizontal members of all trapeze assemblies.

D. Operation and Maintenance Data.

1.9 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC and all local amendments unless requirements in this Section are more stringent.

B. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 FLEXIBLE PIPE CONNECTIONS

A. General: Flexible pipe connectors shall be provided at all piping connections to rotating equipment, isolated equipment and elsewhere as indicated.

1. Basis of Design: Mason Industries, Inc.,
2. Manufacturers:
a. Mason Industries, Inc.
b. Metraflex
c. Twin City Hose
d. Unisource Manufacturing

B. Flexible Spherical Expansion Joints: Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners, and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron an steel flanges with hooked or similar interlocks. Sizes 16" to 24" may be single sphere. Sizes ¾" to 1½" may have threaded bolted flange assemblies, one sphere and cable retention. ¼" and smaller connectors shall be rated at 250 psi up to 190°F with a uniform drop in allowable pressure to 190 psi at 250°F. 16" and larger connectors are rated 180 psi at 190°F and 135 psi at 250°F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5-minute factory test at twice the rated pressure. Concentric reducers to the above specifications may be substituted for equal ended expansion joints. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have ½" thick Neoprene washer bushings large enough in area to take the thrust at 1,000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves. Submittals shall include two test reports by independent consultants showing minimum reductions of 20dB in vibration accelerations and 10dB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Manufacturer shall verify materials are compatible with glycol or other chemicals to be utilized in the piping system.

1. Manufacturer: Mason Industries, Inc., Type "SAFEFLEX SFDEJ, SFEJ, SFDCR, or SFU" with Type "CR" control rods.

C. Flexible Stainless-Steel Hose: Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

<table>
<thead>
<tr>
<th>Flanged</th>
<th>Male Nipples</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 x 14</td>
<td>10 x 26</td>
</tr>
<tr>
<td>4 x 15</td>
<td>12 x 28</td>
</tr>
<tr>
<td>5 x 19</td>
<td>14 x 30</td>
</tr>
<tr>
<td>6 x 20</td>
<td>16 x 32</td>
</tr>
<tr>
<td>8 x 22</td>
<td></td>
</tr>
</tbody>
</table>

Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

1. Manufacturer: Mason Industries, Inc., Type "BSS."
2. Metraflex
3. Unisource Manufacturing
2.2 VIBRATION ISOLATORS

A. General: Provide complete, engineered vibration-isolation systems. Engineering support shall be provided by a representative of the manufacturer, and shall be in full compliance with the manufacturer’s recommendations and the following requirements.

1. Basis of Design: Mason Industries, Inc., utilizing the products specified in the following paragraphs.

2. Manufacturers:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control.
   c. Mason Industries, Inc.
   d. Vibro-Acoustics.

B. General Requirements:

1. Isolator Identification: All vibration isolators shall be clearly marked to show undeflected heights so that after installation and adjustment, deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being attained.

2. Provide a balanced set of isolators for each piece of equipment. Select isolators in accordance with equipment weight distribution to allow for no less than static deflection specified. All isolators for a single piece of equipment shall have approximately equal spring deflection. A minimum of four isolators per unit is required unless otherwise indicated.

3. Each isolator shall be numbered and color-coded to show location. Code number and color shall be marked on plans, on each equipment isolator, and on each base to ensure proper placement.

4. Operating Limits: All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50% above the design deflection.

5. The spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load.

6. The theoretical vertical natural frequency for each support point, based upon the load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than ±10%.

7. Neoprene Mountings: All neoprene mountings shall have a shore hardness of 40–65 after minimum aging of 20 days, or corresponding oven-aging.

8. Neoprene Isolator Formulation: Formulation of the neoprene shall conform to AASHTO specifications for neoprene or ASTM D4014 specification for elastomer.

9. All vibration isolation hardware shall be designed or treated for corrosion resistance. Isolators exposed to the weather shall have steel parts zinc electroplated, PVC coated, plus a coating of neoprene or bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial grade enamel. Nuts, bolts, and washers shall be zinc electroplated.

C. Isolator Type 1: Two layers of ¾" thick neoprene pad consisting of 2" square waffle modules separated horizontally by a 16-gauge galvanized shim. Load distribution plates shall be used as required. Basis of Design: Mason Industries, Inc., Type Super "W."
D. Isolator Type 2: Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2" and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall have an Anchorage Preapproval "OPA" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Basis of Design: Mason Industries, Inc., Type Super "BR."

E. Isolator Type 3: Spring isolators shall be freestanding and laterally stable without any housing and complete with a molded neoprene cup or ¼" neoprene acoustical friction pad between the baseplate and the support. Basis of Design: Mason Industries, Inc. Type "SLF."

F. Isolator Type 4: Restrained spring mountings shall have an SLF mounting as described in Type 3, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position, there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval "OPA" Number from OSHPD in the State of California certifying the maximum certified horizontal and vertical load ratings. Basis of Design: Mason Industries, Inc., Type "SLR."

G. Isolator Type 5: Spring mountings built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of ¼" travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval "OPA" number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Basis of Design: Mason Industries, Inc., Type "SSLFH."

H. Isolator Type 6: Hangers shall consist of rigid steel frames containing minimum 1¼" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Basis of Design: Mason Industries, Inc., Type "30N."

I. Isolator Type 7: Hangers to be pre-compressed and locked at the rated deflection by means of a resilient seismic up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Basis of Design: Mason Industries, Inc., Type "PC30N."

2.3 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Provide complete, engineered equipment bases. Engineering support shall be provided by a representative of the manufacturer, and shall be in full compliance with the manufacturer’s recommendations and the following requirements.

2. Manufacturers:
a. California Dynamics Corporation.
b. Kinetics Noise Control.
c. Mason Industries, Inc.
d. Vibro-Acoustics.

B. Type B-1 Base: Steel Base, factory-fabricated, welded, structural-steel bases and rails.
   1. Design Requirements: Lowest possible mounting height with not less than 1-1/2-inches clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   3. Cross members shall be provided where necessary to support the equipment or to prevent twisting of the main members. The section depth of any frame member shall be not less than 1/10th of the length of the longest frame member and not less than 1/10th of the greatest span between support points. All frame members shall have the same depth.
   4. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Type B-2 Base: A welded structural steel base constructed of angle iron or channels, designed to spread base area of equipment to increase stability and permit suspension with hanger rods.

D. Type B-3 Base: Inertia Base, factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
   1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
   2. Base shall consist of a perimeter welded structural steel pouring form, 1/2" diameter reinforcing bars welded in place on 6" centers each way, pre-located equipment anchor bolts and pipe sleeves, and isolator brackets to reduce the mounting height of the equipment. The bottom edge of the steel reinforcing bars shall be 1-1/2" from bottom of the base. Drilled steel members shall have sleeves below the holes to receive anchor bolts. Thickness of the base shall be a minimum depth of 1/12th of the longest span, but not less than 6" deep. The base shall be sized a minimum overlap of 4" around the base of the equipment, and in the case of belt-driven equipment, 4" beyond the end of the drive shaft.
   3. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
   4. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
   5. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.4 VERTICAL RISER SUPPORTS

A. General: Provide complete engineered pipe riser support systems. Engineering support shall be provided by a representative of the manufacturer, and shall be in full compliance with the
manufacturer’s recommendations and the following requirements. Submittal must be stamped and signed by a licensed professional engineer in the employ of the manufacturer.

1. Basis of Design: Mason Industries, Inc., utilizing the following products:
   a. Support spring mountings; SLF
   b. Anchors; ADA.
   c. Telescoping guides; VSG

2. Manufacturers:
   a. California Dynamics Corporation.
   b. Kinetics Noise Control.
   c. Mason Industries, Inc.

B. Riser Supports: All vertical risers for systems with an operating temperature greater than 105 degrees F. and a height greater than 60 feet, or an operating temperature greater than 200 degrees F. and a height greater than 40 feet, shall be supported by spring isolators designed to support the riser filled with water. Risers that do not fall in these categories may utilize other means of support that will not result in more than 50% variation of force on any point of support under any operating condition.

1. Riser anchors close to the center of the run shall direct movement up and down. The anchors shall be capable of holding an upward force equal to the water weight when the system is drained. Obtain the maximum allowed point loading from the building structural engineer of record. If one level cannot accommodate the anticipated force, anchors can be located on two or three adjacent floors.
2. Steam Risers: If the riser is a steam riser, the design weight should not include water, except the isolators shall not be damaged if the pipe is filled with water. Assigned loads must be within the building design limits at the support points.
3. Long Risers: Provide support spring mountings at levels above and below the anchor level(s) when loading at the anchor level(s) would otherwise exceed the recommendations of the anchor manufacturer, maximum floor loading or would result in an unreasonable stress in the piping system itself.
4. The initial spring deflection shall be a minimum of 0.75” (20mm) or four times the thermal movement at the isolator location, whichever is greater. Calculations shall include pipe stress at end conditions and branch off locations and the manufacturer must include installation instructions.

C. Riser Guides: Provide telescoping guides where needed to maintain riser alignment. Resilient guides shall be spaced and sized properly depending on the pipe diameter. Submittals must include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing. Proper provision shall be made for seismic protection as directed by the Seismic QPE.

D. Coordination at top and bottom of risers: Riser support manufacturer’s engineer shall direct the Contractor on special provisions needed for support and routing of horizontal piping that is connected to the top, bottom and at various midpoints of each riser. Provide additional spring hangers and similar provisions for horizontal piping as required to avoid unreasonable stress on piping and supporting elements.
2.5 SEISMIC-RESTRAINT COMPONENTS

A. Manufacturers:
   1. Basis of Design: Pre-approved products where available from Mason Industries, Inc.,
      custom designed products where not available from Mason Industries, Inc.
   2. Manufacturers:
      a. International Seismic Application Technology (ISAT).
      b. Kinetics Noise Control.
      c. Mason Industries, Inc.

B. General Requirements for Restraint Components: Rated strengths, features, and applications
   shall be as defined in reports by an evaluation service member of ICC-ES or OSHPD.
   1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of
      components shall be at least four times the maximum seismic forces to which they will
      be subjected.
   2. Even though the project may not be located in the State of California, all isolators that
      provide seismic restraint shall have an Anchorage Preapproval "OPA" Number from
      OSHPD (of the State of California) verifying the maximum certified load ratings.
   3. Seismic Cable Restraints consisting of galvanized steel aircraft cables shall be provided
      for vibration-isolated components.
   4. Seismic Solid Braces consisting of steel angles or channels shall be provided for all
      suspended components that are not vibration-isolated.
   5. Pipe clevis cross bolt braces are required in all restraint locations
   6. Provide hanger rod reinforcing to prevent buckling due to upward forces caused by
      restraints.

C. Base-mounted equipment with vibration isolation: Where integral seismic restraints furnished
   with vibration isolators are not adequate, provide all-directional seismic snubbers consisting of
   interlocking steel members restrained by a one-piece molded neoprene bushing of bridge
   bearing neoprene.

D. Restraint Anchors: Provide appropriate anchors to attach equipment, seismic restraints, and
   vibration isolation devices (if being used for seismic restraint), to the building structure. The
   method of connection to the structure shall be identified at each location on the Layout
   Drawings. All components shall meet the requirements of the authorities having jurisdiction.
   Where available, anchors (such as wedge anchors) shall have an evaluation report number from
   the ICBO Evaluation Service, Inc. verifying its allowable loads

2.6 FACTORY FINISHES

A. All vibration isolation and seismic restraint hardware shall be designed or treated for corrosion
   resistance.

B. Items exposed to the weather shall have steel parts zinc electroplated, PVC coated, plus a
   coating of neoprene or bitumastic paint. Aluminum components for outdoor installation shall
   be etched and painted with industrial enamel.
C. Nuts, bolts, and washers shall be zinc electroplated.

D. Structural steel bases shall be thoroughly cleaned of welding slag, primed with zinc chromate and finished with two coats of industrial enamel.

E. Field painting shall comply with requirements in Division 09. Verify compatibility of factory finishes with field-applied coats.

PART 3 - EXECUTION

3.1 VIBRATION ISOLATION INSTALLATION REQUIREMENTS

A. Vibration Isolation for Piping:

1. When piping connects to equipment is provided with vibration isolation and a flexible connection is not provided at the equipment, the first four pipe hangers shall be Type 7 with the same deflection as specified for the mountings under the connected equipment.
2. Floor supported piping shall be isolated with Type 4 isolators.
3. Do not support vibration isolated piping along with non-isolated piping on a common trapeze.
4. Steel spring hanger boxes shall be rigidly mounted to the supporting structure-not located in the middle of the hanger rod.
5. Hanger rods shall be aligned to clear the hanger box.
6. Load-transfer isolators, when utilized, shall temporarily maintain the piping in a rigid position until installation is complete and fully loaded.
7. Pipe anchors are not permitted in vibration isolated piping circuits.

B. General Requirements for Equipment Bases:

1. All bases shall be installed on housekeeping pads. All bases shall be sized to include equipment and motor without overhang.
2. Motor-driven equipment shall be mounted with motors on a common base of sufficient rigidity to maintain permanent alignment.
3. All bases shall have clearance of 1-1/2” between top of floor and underside of base.
4. Inertia bases shall have 1-1/2” clearance for first 50 sq.ft. of area.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION REQUIREMENTS

A. Install seismic restraints for all equipment and all sizes of ductwork and piping except where omission of restraints for smaller sizes is specifically allowed by Code and specifically allowed by the QPE and seismic restraint manufacture’s guidelines.

B. Install cables so they do not bend across edges of adjacent equipment or building structure.

C. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.
D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

G. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. The seismic QPE shall review all piping and ductwork that crosses building seismic joints and shall select or design appropriate restraints on both sides. Consider the anticipated displacement of the building structure at the joints and the flexibility of the specified duct and piping components when determining placement of restraints. If displacement will result in excessive forces within the ductwork or piping itself, which cannot be mitigated by restraint placement, contact the A/E for direction.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after piping system is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230540
SECTION 230550 - IDENTIFICATION FOR PIPING AND EQUIPMENT

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 SUBMITTALS

A. Product Data: Submit for each type of product indicated.
B. Valve numbering scheme.
C. Valve Schedules: For each piping system to include in maintenance manuals.

1.3 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
B. Coordinate installation of identifying devices with locations of access panels and doors.
C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8-inch-thick, and having predrilled holes for attachment hardware.
   4. Maximum Temperature: Able to withstand temperatures up to 160-degree F.
   5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   7. Fasteners: Stainless-steel rivets or self-tapping screws.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
B. Label Content: Include equipment's Drawing designation or unique equipment number.

2.2 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.

2. Lettering Size: As appropriate for pipe size.

2.3 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.

2. Fasteners: Brass beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.
3.3 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions.

3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230550
SECTION 230590 - TESTING ADJUSTING AND BALANCING

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.

B. Division 23, Section 230500 is directly related. Other sections are indirectly related and shall be reviewed.

1.2 SUMMARY

A. Work under this section shall include furnishing all labor, materials, tools, and equipment necessary for testing, adjusting, and balancing (TAB) necessary to place all systems and items of equipment, specified in Division 23, in proper operating condition. All work shall be completely tested as required by this section and applicable city, county, and state codes and ordinances.

B. Submit copies of all testing, adjusting, and balancing data to A/E.

C. Leak and pressure testing of piping and duct systems and rotational testing of motors shall be performed by the installing contractor.

D. TAB shall include the following:

1. Air Systems:
   a. Constant-volume air systems.
   b. Dual-duct systems.
   c. Variable-air-volume systems.
   d. Multizone systems.

2. Hydronic Piping Systems:
   a. Constant-flow systems.
   b. Variable-flow systems.
   c. Primary-secondary systems.

3. HVAC equipment quantitative-performance settings.
5. Exhaust hood airflow balancing.
6. Space pressurization testing and adjusting.
8. Sound level measuring.
9. Smoke-control systems testing and adjusting.
10. Indoor-air quality measuring.
11. Verifying that automatic control devices are functioning properly.
12. Domestic water recirculation systems.
13. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.

B. Air Systems: Includes all outside air, supply air, return air, transfer air, exhaust air, relief air and make-up air systems.

C. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

D. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.

E. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.

F. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

G. Hydronic Systems: Includes chilled water, condenser water, heating hot water, and glycol-water systems, and heat recovery water systems.

H. NC: Noise criteria.

I. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

J. RC: Room criteria.

K. Report Forms: Test data sheets for recording test data in logical order.

L. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

M. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

N. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

O. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
P. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

Q. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

R. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

S. TAB: Testing, adjusting, and balancing.

T. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

U. Terminal Unit: A device that controls the temperature and/or volume of air that enters or leaves a zone.

V. Test: A procedure to determine quantitative performance of systems or equipment.

W. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

X. Zone: The space that is controlled by a terminal unit or other temperature controlling device.

1.4 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit two copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 45 days from Contractor's Notice to Proceed, submit two copies of the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit two copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Contracting: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.

B. TAB Firm Qualifications:
1. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the A/E and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency’s review shows unsatisfactory work performed by the predecessor agency.

2. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the A/E and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.

3. TAB Specialist Responsibilities:
   a. The General Contractor, within 60 days after the notice to proceed, shall identify TAB specialist who would be responsible for supervising, coordinating, scheduling and reporting all TAB work and related activities and provide necessary information as required by the A/E.
   b. All TAB work shall be performed under the direct supervision of the TAB specialist.
   c. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB. The reports shall be signed by the TAB specialist and shall bear the seal of the TAB standard.
   d. The TAB Specialist would follow all TAB work through its satisfactory completion.
   e. Final markings of settings of all HVAC adjustment devices.
   f. Permanently mark location of duct test ports.

4. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of three projects comparable in size and complexity of this project and must be certified so by the TAB agency in writing.

C. Test Equipment Criteria: The basic instrumentation requirements and accuracy/calibration required by AABC, National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

1. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
2. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.
D. Tab Criteria:

1. One or more of the applicable AABC or NEBB publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, and requirements stated herein shall be the basis for planning, procedures, and reports.

2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "HVAC Applications", Chapter 36 as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 90 percent of final values for pre-filters and after-filters.
   a. Air handling unit and all other fans, cubic feet per minute: Minus 0 percent to plus 10 percent.
   b. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
   c. Exhaust hoods/cabinets: 0 percent to plus 10 percent.
   d. Minimum outside air: 0 percent to plus 10 percent.
   e. Individual rooms: air outlets and inlets, and air flow rates not mentioned above: Minus 2 percent to plus 10 percent.
   f. Individual rooms where both supply and return/exhaust air volume is indicated: Unless the A/E confirms that room pressurization is not a requirement, the difference between the total supply to a room and the total exhaust/return from that same room shall be 0 percent to plus 10 percent. The required difference is determined by subtracting one total (sum of values indicated at terminals in the room) from the other.
   g. Heating hot water pumps: Minus five percent to plus five percent.
   h. Chilled water and condenser water pumps and coils: 0 percent to plus five percent.

3. Systems shall be adjusted for energy efficient operation as described in PART 3.

4. Typical TAB procedures and results shall be demonstrated to the A/E for one air distribution system (including all fans, three terminal units, three rooms) and one hydronic system (pumps and three coils) as follows:
   a. When field TAB work begins.
   b. During each partial final inspection and the final inspection for the project if requested by Owner.

E. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location. Agenda Items: Include at least the following:

1. Submittal distribution requirements.
3. TAB plan.
4. Work schedule and Project-site access requirements.
5. Coordination and cooperation of trades and subcontractors.
6. Coordination of documentation and communication flow.

F. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

G. TAB Report Forms: Use standard forms from AABC’s "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB’s "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

H. Instrumentation Type, Quantity, and Accuracy: As described in AABC’s "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB’s "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, " Section II, " Required Instrumentation for NEBB Certification."

I. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

A. National Project Performance Guarantee: Provide a guarantee on AABC’s "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include the following provisions:

1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
2. Systems are balanced to optimum performance capabilities within design and installation limits.

1.9 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text, the publications are referenced to by the initials of the organization.


D. National Environmental Balancing Bureau (NEBB):


PART 2 - PRODUCTS

2.1 PLUGS

A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

A. See Division 23, Section 23070, "Mechanical Insulation". Provide for repair of insulation removed or damaged for TAB work.

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.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01,017839, Section "Project Record Documents."

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 equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems-Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
L. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

M. Examine strainers for clean screens and proper perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

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

P. Examine system pumps to ensure absence of entrained air in the suction piping. Verify that start-up strainers have been removed from the pump suction diffusers.

Q. Examine equipment for installation and for properly operating safety interlocks and controls.

R. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Spot-check thermostats to determine if they have been calibrated by the Control Contractor.
   7. Sensors are located to sense only the intended conditions.
   8. Sequence of operation for control modes is according to the Contract Documents.
   9. Controller set points are set at indicated values.
   10. Interlocked systems are operating.
   11. Changeover from heating to cooling mode occurs according to indicated values.

S. 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 system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 SYSTEMS INSPECTION REPORT

A. Inspect equipment and installation for conformance with design.

B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.

C. Reports: Follow check list format developed by AABC or NEBB supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including flexible duct sizes and routing.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

B. Coordinate TAB procedures with any phased construction completion requirements for the project. Provide TAB reports for each phase of the project prior to partial final inspections of each phase of the project.

C. Allow sufficient time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

D. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

E. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

F. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

G. Take and report testing and balancing measurements in inch-pound (IP) units.
3.5 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. For variable-air-volume systems, develop a plan to simulate diversity.

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

E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

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

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

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

I. Check for airflow blockages.

J. Check condensate drains for proper connections and functioning.

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

L. Check for proper sealing of air duct system.

3.6 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 fan static pressures to determine actual static pressure as follows:

   a. Measure outlet static pressure as far downstream from the fan as practicable 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 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.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. 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 modes 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 static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved. 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. 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 terminal outlets and inlets without making adjustments. Measure terminal outlets using a direct-reading hood or outlet manufacturer’s written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using 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.

3.7 PROCEDURES FOR DUAL-DUCT SYSTEMS

A. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.

B. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate mixing-box controls and to overcome resistance in the ducts and outlets downstream from mixing box. If insufficient static pressure exists, increase the airflow at the fan.

C. Test and adjust the constant-volume mixing boxes as follows:

1. Verify both hot and cold operations by adjusting the thermostat and observing the air temperature and volume changes.
2. Verify sufficient inlet static pressure before making volume adjustments.
3. Adjust mixing box to indicated airflows within specified tolerances. Measure the airflow by Pitot-tube traverse readings, totaling the airflow of the outlets; or by measuring static pressure at mixing-box taps if provided by box manufacturer.

D. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate mixing-box controls and to overcome resistance in the ducts and outlets downstream from mixing box.

E. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume dual-duct systems, and adjust each mixing-box maximum- and minimum-airflow settings.

3.8 PROCEDURES FOR MULTIZONE SYSTEMS
A. Set unit at full flow through the cooling coil if coil has that capacity.
B. Adjust each zone damper to indicated airflow.

3.9 PROCEDURES FOR MOTORS
A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
   1. Manufacturer, model, and serial numbers.
   4. Efficiency rating.
   5. Nameplate and measured voltage, each phase.
   6. Nameplate and measured amperage, each phase.
   7. Starter thermal-protection-element rating.
B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.10 PROCEDURES FOR CONDENSING UNITS
A. Verify proper rotation of fans.
B. Measure entering- and leaving-air temperatures.
C. Record compressor data.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS
A. Water Coils: Measure the following data for each coil:
   1. Entering- and leaving-water temperature.
3.12 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.

3.13 PROCEDURES FOR EXHAUST HOODS

A. Measure, adjust, and record the airflow of each exhaust hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.

B. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.
2. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.
3.14 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
   1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
   2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
   3. Test room pressurization first, then zones, and finish with building pressurization.

D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
   1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
   2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
   3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.15 PROCEDURES FOR VIBRATION MEASUREMENTS

A. Use a vibration meter meeting the following criteria:
   1. Solid-state circuitry with a piezoelectric accelerometer.
   2. Velocity range of 0.1 to 10 inches per second (2.5 to 254 mm/s).
3. Displacement range of 1 to 100 mils (0.0254 to 2.54 mm).
4. Frequency range of at least 0 to 1000 Hz.
5. Capable of filtering unwanted frequencies.

B. Calibrate the vibration meter before each day of testing.
   1. Use a calibrator provided with the vibration meter.
   2. Follow vibration meter and calibrator manufacturer's calibration procedures.

C. Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.
   1. Turn off equipment in the building that might interfere with testing.
   2. Clear the space of people.

D. Perform vibration measurements after air and water balancing and equipment testing is complete.

E. Clean equipment surfaces in contact with the vibration transducer.

F. Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

G. Measure and record vibration on rotating equipment over 3 hp.

H. Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.
   1. Pumps:
      a. Pump Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Pump Base: Top and side.
      d. Building: Floor.
      e. Piping: To and from the pump after flexible connections.
   2. Fans and HVAC Equipment with Fans:
      a. Fan Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
      c. Equipment Casing: Top and side.
      d. Equipment Base: Top and side.
      e. Building: Floor.
      f. Ductwork: To and from equipment after flexible connections.
      g. Piping: To and from equipment after flexible connections.
   3. Chillers and HVAC Equipment with Compressors:
      a. Compressor Bearing: Drive end and opposite end.
      b. Motor Bearing: Drive end and opposite end.
c. Equipment Casing: Top and side.
d. Equipment Base: Top and side.
e. Building: Floor.
f. Piping: To and from equipment after flexible connections.

I. For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

J. Inspect, measure, and record vibration isolation.
   1. Verify that vibration isolation is installed in the required locations.
   2. Verify that installation is level and plumb.
   3. Verify that isolators are properly anchored.
   4. For spring isolators, measure the compressed spring height, the spring OD, and the travel-to-solid distance.
   5. Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.16 PROCEDURES FOR SOUND-LEVEL MEASUREMENTS

A. Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

B. Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

C. Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm (0.51 m/s), use a windscreen on the microphone.

D. Perform sound-level testing after air and water balancing and equipment testing are complete.

E. Close windows and doors to the space.

F. Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

G. Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of-sight between the sound source and the sound-level meter.

H. Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.

I. Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.
J. Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating. Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

K. Perform sound testing at <Insert number> locations on Project for each of the following space types. For each space type tested, select a measurement location that has the greatest sound level. If testing multiple locations for each space type, select at least one location that is near and at least one location that is remote from the predominant sound source.

1. Private office.
2. Open office area.
3. Conference room.
4. Auditorium/large meeting room/lecture hall.
5. Classroom/training room.
6. Patient room/exam room.
7. Sound or vibration sensitive laboratory.
8. Hotel room/apartment.
9. Each space with a noise criterion of RC or NC 25 or lower.
10. Each space with an indicated noise criterion of RC or NC 35 and lower that is adjacent to a mechanical equipment room or roof mounted equipment.
11. Inside each mechanical equipment room.

3.17 PROCEDURES FOR INDOOR-AIR QUALITY MEASUREMENTS

A. After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.

B. Observe and record the following conditions for each HVAC system:

1. The distance between the outside-air intake and the closest exhaust fan discharge, cooling tower, flue termination, or vent termination.
2. Specified filters are installed. Check for leakage around filters.
3. Cooling coil drain pans have a positive slope to drain.
4. Cooling coil condensate drain trap maintains an air seal.
5. Evidence of water damage.
6. Insulation in contact with the supply, return, and outside air is dry and clean.

C. Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:

1. Most remote area.
2. One location per floor.
3. One location for every 5000 square feet (500 sq. m).

D. Measure and record the following indoor conditions for each location two times at two-hour intervals, and in accordance with ASHRAE 113:

1. Temperature.
2. Relative humidity.
3. Air velocity.
5. Concentration of carbon monoxide (ppm).
7. Formaldehyde (ppm).

3.18 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.19 PROCEDURES FOR DOMESTIC WATER MEASUREMENTS

A. Balance recirculation lines to values shown on plans

B. Record flow rates for reach circuit setter.

3.20 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus five to plus 10 percent.
2. Air Outlets and Inlets: 0 to minus 10 percent.
3. Heating-Water Flow Rate: 0 to minus 10 percent.
4. Cooling-Water Flow Rate: 0 to minus five percent.
3.21 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: As Work progresses, prepare 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.

3.22 FINAL REPORT

A. General: Computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:

1. Title page.
2. Name and address of TAB firm.
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 firm 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, type size, and fittings.
14. Notes to explain why certain final data in the body of reports varies from indicated values.
15. Test conditions for fans and pump performance forms including the following:
   a. Settings for outside-, 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.

E. 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 outside, 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.

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 (mm) o.c.
   f. Make and model number.
   g. Face area in square feet (sq. m).
   h. Tube size in NPS (DN).
   i. Tube and fin materials.
   j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outside-air, wet- and dry-bulb temperatures in degree F (degree C).
   e. Return-air, wet- and dry-bulb temperatures in degree F (degree C).
   f. Entering-air, wet- and dry-bulb temperatures in degree F (degree C).
g. Leaving-air, wet- and dry-bulb temperatures in degree F (degree C).
h. Water flow rate in gpm (L/s).
i. Water pressure differential in feet of head or psig (kPa).
j. Entering-water temperature in degree F (degree C).
k. Leaving-water temperature in degree F (degree C).
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig (kPa).
n. Refrigerant suction temperature in degree F (degree C).
o. Inlet steam pressure in psig (kPa).

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:
   a. System identification.
   b. Location.
   c. Coil identification.
   d. Capacity in Btuh (kW).
   e. Number of stages.
   f. Connected volts, phase, and hertz.
   g. Rated amperage.
   h. Airflow rate in cfm (L/s).
   i. Face area in square feet (sq. m).
   j. Minimum face velocity in fpm (m/s).

2. Test Data (Indicated and Actual Values):
   a. Heat output in Btuh (kW).
   b. Airflow rate in cfm (L/s).
   c. Air velocity in fpm (m/s).
   d. Entering-air temperature in degree F (degree C).
   e. Leaving-air temperature in degree F (degree C).
   f. Voltage at each connection.
   g. Amperage for each phase.

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 (mm), and bore.
   h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

2. Motor Data:
a. 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 (mm), and bore.
f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
g. Number of belts, make, and size.

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

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 degree F (degree C).
      d. Duct static pressure in inches wg (Pa).
      e. Duct size in inches (mm).
      f. Duct area in square feet (sq. m).
      g. Indicated airflow rate in cfm (L/s).
      h. Indicated velocity in fpm (m/s).
      i. Actual airflow rate in cfm (L/s).
      j. Actual average velocity in fpm (m/s).
      k. Barometric pressure in psig (Pa).

J. Air-Terminal-Device Reports:
   1. Unit Data:
      a. System and air-handling unit identification.
      b. Location and zone.
      c. Test apparatus used.
      d. Area served.
      e. Air-terminal-device make.
      f. Air-terminal-device number from system diagram.
      g. Air-terminal-device type and model number.
      h. Air-terminal-device size.
      i. Air-terminal-device effective area in square feet (sq. m).
   2. Test Data (Indicated and Actual Values):
      a. Airflow rate in cfm (L/s).
      b. Air velocity in fpm (m/s).
c. Preliminary airflow rate as needed in cfm (L/s).
d. Preliminary velocity as needed in fpm (m/s).
e. Final airflow rate in cfm (L/s).
f. Final velocity in fpm (m/s).
g. Space temperature in degree F (degree C).

K. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Unit make and model number.
   d. Compressor make.
   e. Compressor model and serial numbers.
   f. Refrigerant weight in lb (kg).
   g. Low ambient temperature cutoff in degree F (degree C).

2. Test Data (Indicated and Actual Values):
   a. Inlet-duct static pressure in inches wg (Pa).
   b. Outlet-duct static pressure in inches wg (Pa).
   c. Entering-air, dry-bulb temperature in degree F (degree C).
   d. Leaving-air, dry-bulb temperature in degree F (degree C).
   e. Condenser entering-water temperature in degree F (degree C).
   f. Condenser leaving-water temperature in degree F (degree C).
   g. Condenser-water temperature differential in degree F (degree C).
   h. Condenser entering-water pressure in feet of head or psig (kPa).
   i. Condenser leaving-water pressure in feet of head or psig (kPa).
   j. Condenser-water pressure differential in feet of head or psig (kPa).
   k. Control settings.
   l. Unloader set points.
   m. Low-pressure-cutout set point in psig (kPa).
   n. High-pressure-cutout set point in psig (kPa).
   o. Suction pressure in psig (kPa).
   p. Suction temperature in degree F (degree C).
   q. Condenser refrigerant pressure in psig (kPa).
   r. Condenser refrigerant temperature in degree F (degree C).
   s. Oil pressure in psig (kPa).
   t. Oil temperature in degree F (degree C).
   u. Voltage at each connection.
   v. Amperage for each phase.
   w. Kilowatt input.
   x. Crankcase heater kilowatt.
   y. Number of fans.
   z. Condenser fan rpm.
   aa. Condenser fan airflow rate in cfm (L/s).
   bb. Condenser fan motor make, frame size, rpm, and horsepower.
   cc. Condenser fan motor voltage at each connection.
dd. Condenser fan motor amperage for each phase.

L. Air-to-Air Heat-Recovery Unit Reports:

1. Unit Data:
   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and type.
   e. Model and serial numbers.

2. Motor Data:
   a. 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 (mm), and bore.
   f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

3. If fans are an integral part of the unit, include the following for each fan:
   a. Make and type.
   b. Arrangement and size.
   c. Sheave make, size in inches (mm), and bore.
   d. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

4. Test Data (Indicated and Actual Values):
   a. Total exhaust airflow rate in cfm (L/s).
   b. Purge exhaust airflow rate in cfm (L/s).
   c. Outside airflow rate in cfm (L/s).
   d. Total exhaust fan static pressure in inches wg (Pa).
   e. Total outside-air fan static pressure in inches wg (Pa).
   f. Pressure drop on each side of recovery wheel in inches wg (Pa).
   g. Exhaust air temperature entering in degree F (degree C).
   h. Exhaust air temperature leaving in degree F (degree C).
   i. Outside-air temperature entering in degree F (degree C).
   j. Outside-air temperature leaving in degree F (degree C).
   k. Calculate sensible and total heat capacity of each airstream in MBh (kW).

M. Vibration Measurement Reports:

1. Date and time of test.
2. Vibration meter manufacturer, model number, and serial number.
3. Equipment designation, location, equipment, speed, motor speed, and motor horsepower.
4. Diagram of equipment showing the vibration measurement locations.
5. Measurement readings for each measurement location.
7. Description of predominant vibration source.
N. Sound Measurement Reports: Record sound measurements on octave band and dBA test forms and on an NC or RC chart indicating the decibel level measured in each frequency band for both "background" and "HVAC system operating" readings. Record each tested location on a separate NC or RC chart. Record the following on the forms:

1. Date and time of test. Record each tested location on its own NC curve.
2. Sound meter manufacturer, model number, and serial number.
3. Space location within the building including floor level and room number.
4. Diagram or color photograph of the space showing the measurement location.
5. Time weighting of measurements, either fast or slow.
6. Description of the measured sound: steady, transient, or tonal.
7. Description of predominant sound source.

O. Indoor-Air Quality Measurement Reports for Each HVAC System:

1. HVAC system designation.
2. Date and time of test.
3. Outdoor temperature, relative humidity, wind speed, and wind direction at start of test.
4. Room number or similar description for each location.
5. Measurements at each location.
6. Observed deficiencies.

P. Instrument Calibration Reports to Include:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

3.23 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. Randomly check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least five percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Measure sound levels at two locations.
   e. Measure space pressure of at least 10 percent of locations.
   f. Verify that balancing devices are marked with final balance position.
   g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:
1. After initial inspection is complete and evidence 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 [Owner] [Architect].

2. TAB firm test and balance engineer shall conduct the inspection in the presence of [Owner] [Architect].

3. [Owner] [Architect] shall randomly select measurements documented in the final report to be rechecked. The 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 eight-hour business day.

4. If the 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.

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.24 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

3.25 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230590
SECTION 230700 - HVAC INSULATION 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: Insulation materials and accessories.

B. New Work: Completely insulate all new work as specified and scheduled.

C. Existing Work:
   1. Insulate all existing piping and ductwork where existing insulation is damaged, as if it is new piping or ductwork.
   2. Insulate all existing piping and ductwork that is currently not insulated, as if it is new piping or ductwork.

D. Coordination:
   1. Coordinate size and location of supports, hangers, and insulation shields specified in other sections.
   2. Coordinate clearance requirements with piping installer for piping insulation application, duct installer for duct insulation application, and equipment installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
   3. Coordinate installation and testing of heat tracing.

1.3 SUBMITTALS

A. Product Data: Submit for each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:
   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.
8. Detail field application for each equipment type.
9. Make reference to applicable specification paragraph numbers (of the items discussed above) for coordination.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

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.

1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23, Section 230500, “Common Work Results for HVAC.”

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment 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 before installation of insulation.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

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. Thermal Requirements for all Insulation: Insulation thickness, conductivity (k) value and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

2.2 PIPE INSULATION

A. Glass Fiber Preformed Pipe Insulation: Glass fiber meeting ASTM C547, rigid molded. "K" value 0.23 at 75°F. Maximum service temperature shall not exceed 850°F. Jacket shall be high density, white Kraft bonded to aluminum foil for vapor barrier, reinforced with fiberglass yarn, permanently treated, secured with self-sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples coated with vapor barrier mastic.

1. For interior use only. Do not use on exterior piping.
2. Basis of Design: Johns Manville "Micro-Lok HP."
3. Manufacturers:
   a. Johns Manville "Micro-Lok HP."
   b. Knauf Insulation "Earthwool 1000 Pipe Insulation."
   c. Owens-Corning “Fiberglas SSLII-ASJ.”

   a. Preformed Pipe Insulation: ASJ.

B. Polyisocyanurate Preformed Pipe Insulation: Rigid molded polyisocyanurate pipe insulation shall meet the requirements of ASTM C591 Type IV. Materials shall have a minimum thermal conductivity of 0.19 Btu-in. per sq.ft. per °F per hour at a mean temperature of 75°F when tested in accordance with ASTM C177 or ASTM C518, latest revisions. Maximum service temperature shall not exceed 300°F. The pipe insulation shall include a vapor retarder jacket with self-sealing longitudinal laps.

2. Manufacturers:
   a. HiTherm HT-300.
   b. Other Polyisocyanurate manufacturers shall be allowed only if they meet fire and smoke rating requirements for the specified thicknesses.

   a. Preformed Pipe Insulation: ASJ.

C. Phenolic: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.

1. Basis of Design: Resolco; Insul-Phen.
2. Manufacturers:
   a. Dyplast Products; DyTherm.
   b. ITW Insulation Systems; Trymer Supercel.
   c. Resolco; Insul-Phen.

   a. Preformed Pipe Insulation: ASJ.

D. Calcium Silicate Pipe Insulation (Use only for inserts for fiber glass insulation at pipe supports): Rigid molded pipe insulation, asbestos-free, meeting ASTM C533, color coded throughout, “K” value 0.40 at 300°F, maximum service temperature 1200°F, minimum compressive strength of block form not less than 200 psi with 5% compression at 1-1/2" thickness. Non-combustible tested per ASTM E-136. Secured with 16-gauge stainless steel tie wire with twisted ends on maximum 12-inch centers.

1. Basis of Design: Johns Manville "Thermo-12 Gold."
2. Manufacturers:
   a. Johns Manville "Thermo-12 Gold."
   b. Industrial Insulation Group "Super Caltemp Gold."

   a. Preformed Pipe Insulation: ASJ.

E. Cellular Glass Pipe Insulation: Inorganic, closed cell, all glass, non-combustible with 0.2% (by volume) moisture absorption. Average density of 8 lb./cu. ft., 100 psi compressive strength, 900°F service temperature, 0.35 BTU/in./hr/sf/°F conductivity.

1. Basis of Design: Pittsburgh Corning "Foamglas One."
2. Manufacturers:
   a. Cell-U-Foam Corporation "Ultra-CUF".
   b. Pittsburgh Corning "Foamglas One."

   a. Preformed Pipe Insulation: ASJ.

F. EPDM rubber, flexible, closed-cell elastomeric insulation in tubular or sheet form. The product will meet the requirements defined in ASTM C 534.

2. Manufacturers:
   a. Aeroflex USA Inc.; Aerocel AC, Aerocel White/Gray, Aerocel-SSPT, Aerocel W/G-SSPT, or Aerocel SA.
   b. Armacell LLC; AP Armaflex.
   c. Industrial Thermo Polymers Limited; Tundra Seal.
3. EPDM elastomeric insulation shall have a flame-spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E 84, for all products through 2” thickness.
4. Product to be suitable for use from -297°F to 300°F continuous service temperature, per ASTM C 411.
5. EPDM elastomeric insulation shall have a maximum thermal conductivity of 0.245 Btu-in./h-ft²F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518.
   a. Preformed Pipe Insulation: ASJ.

2.3 EQUIPMENT AND DUCTWORK INSULATION

A. Thermal Requirements for all Equipment Insulation: Insulation thickness and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

B. Glass or 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 III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   2. Manufacturers:
      a. CertainTeed Corp.; SoftTouch Duct Wrap.
      b. Johns Manville; Microlite XG.
      c. Knauf Insulation; Duct Wrap.
      d. Manson Insulation Inc.; Alley Wrap.
      e. Owens Corning; Softr Duct Wrap FRK.

C. Glass or Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Basis of Design: CertainTeed Corp.; CertaPro Commercial Board.
   2. Manufacturers:
      a. CertainTeed Corp.; CertaPro Commercial Board.
      b. Johns Manville; 1000 Series Spin-Glas.
      c. Knauf Insulation; Insulation Board.
      d. Owens Corning; Fiberglas 700 Series.

D. Cellular Glass Insulation: Inorganic, closed cell, all glass, non-combustible with 0.2% (by volume) moisture absorption. Average density of 8 lb./cu. ft., 100 psi compressive strength, 900°F service temperature, 0.35 BTU/in./hr/ft²°F conductivity, R-value = 3.44 per inch.
   1. Basis of Design: Pittsburgh Corning "Foamglas One."
2. Manufacturers:
   a. Cell-U-Foam Corporation "Ultra-CUF".
   b. Pittsburgh Corning "Foamglas One."

   a. Block Insulation: ASTM C 552, Type I.
   b. Special-Shaped Insulation: ASTM C 552, Type III.
   c. Board Insulation: ASTM C 552, Type IV.
   d. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

2.4 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.
   1. Basis of Design: 3M; Fire Barrier Duct Wrap 615 Plus.
   2. Manufacturers:
      a. CertainTeed Corp.; Fyre Wrap Max 2.0.
      b. Johns Manville; Firetemp SL-2.0 Wrap.
      c. 3M; Fire Barrier Duct Wrap 615 Plus.

2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

B. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

C. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

D. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

E. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
   1. Manufacturers:
      a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
F. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

1. Manufacturers:
   a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.


1. Manufacturers:
   a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.6 FIELD APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

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

C. Jacketing of Ducts and Pipes Exposed to Weather: All ductwork and piping exposed to weather shall be finished with an aluminum jacket over the insulation. Aluminum jacket material shall be embossed or corrugated sheet, 0.016" nominal thickness, conforming to ASTM B209, temper H-14. Jacketing shall be applied with joints lapped not less than 2", and shall be secured with 3/8" x 0.020" thick aluminum bands located at each circumferential lap and at not more than 9" intervals throughout. Horizontal joints shall lap downward to shed water. Vertical joints shall be sealed with weatherproof silicone sealant.

1. Basis of Design: Childers Products, Division of ITW "Metal Jacketing Systems."
2. Manufacturers:
   a. Childers Products, Division of ITW.
   b. Pabco Metals Corporation.
   c. RPR Products Inc, "Insul-Mate".

Be careful to consider jacketing requirements for piping that may be outdoors, but not exposed to weather. Such piping may include piping in parking garages, within covered loading docks, etc. Make sure documents adequately address different requirements for different situations.

D. PVC Plastic: One-piece molded type fitting covers and jacketing material, gloss white. Connections, tacks, pressure sensitive color matching vinyl tape. PVC material shall be 25 flame spread and 50 smoke development rated per ASTM E-84.

1. Basis of Design: Johns Manville "Zeston 2000 PVC".
2. Manufacturers:
   a. Johns Manville "Zeston 2000 PVC".
   b. Proto Engineered Thermoplastics Corp. "Proto Fitting Cover System".

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d. Speedline Corporation "Smoke-Safe".

E. **PVDC-SSL Jacket:** PVDC jacket with a self-sealing, pressure sensitive, acrylic-bases adhesive covered by a removable protective strip.

1. **Basis of Design:** Dow Chemical Company Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder tape.
2. **Manufacturers:**
   a. Dow Chemical Company Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder tape.

F. **Underground Cellular Glass Pipe Jacket:** The underground direct buried jacket shall be 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.

1. **Basis of Design:** Pittsburgh Corning "Pittwrap CW Plus" with "Pittcoate 300."
2. **Manufacturers:**
   a. Pittsburgh Corning "Pittwrap CW Plus" with "Pittcoate 300."
   b. Polyguard "Insulrap No Torch 125".

G. **Canvas Jacket:** UL listed fabric, 6 oz/sq.yd.plain weave cotton treated with dilute fire-retardant lagging adhesive. Manufacturer: Great Lakes Textiles Product Style 1979.

H. **Woven Glass-Fiber Fabric:** Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

I. **Butt Straps:** Materials shall be identical in all respects and appearance to the basic jacket material.

2.7 **INSULATING CEMENTS**

A. **Mineral-Fiber Insulating Cement:** Comply with ASTM C 195.

1. **Basis of Design:** P. K. Insulation Mfg. Co., Inc.; "Super-Stik".
2. **Manufacturers:**
   a. Insulco, Division of MFS, Inc.; "Triple I"
   c. Ramco Insulation, Inc.; "Supertemp 1900".

B. **Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement 100 to 1200 degree:** Comply with ASTM C 449/C 449M.

1. **Basis of Design:** P. K. Insulation Mfg. Co., Inc" PK No. 127" and "Quik-Cote".
2. **Manufacturers:**
   a. Insulco, Division of MFS, Inc.; "SmoothKote".
b. P. K. Insulation Mfg. Co., Inc.; "Quik-Cote".
c. Ramco Insulation, Inc.; "Ramcote 1200".
d. Rock Wool Manufacturing Company; "Delta One Shot".

2.8 ADHESIVES AND MASTICS

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. Obtain insulation and/or jacket manufacturer approval for all adhesives and mastics used. Obtain A/E approval for all locations where mastics will be used.

1. Adhesives shall not be considered an acceptable alternative to specified mechanical fastening methods without prior A/E approval.
2. All adhesives and mastics shall be suitable for the moisture conditions and temperatures that will be encountered.

B. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

1. Basis of Design: Childers Products, Division of ITW; CP-96.
2. Manufacturers:
   a. Childers Products, Division of ITW; CP-96.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

2. Manufacturers:
   a. Aeroflex USA Inc.; Aeroseal.
   b. Armacell LCC; 520 Adhesive.
   c. Foster Products Corporation, H. B. Fuller Company; 85-75.
   d. RBX Corporation; Rubatex Contact Adhesive.

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

1. Basis of Design: Childers Products, Division of ITW; CP-82.
2. Manufacturers:
   a. Childers Products, Division of ITW; CP-82.
   c. Marathon Industries, Inc.; 225.
   d. Mon-Eco Industries, Inc.; 22-25.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

2. Manufacturers:
F. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Basis of Design: Childers Products, Division of ITW; CP-35.
2. Manufacturers:
   a. Childers Products, Division of ITW; CP-35.
   b. Foster Products Corporation, H. B. Fuller Company; 30-90.
   c. Marathon Industries, Inc.; 590.
   d. Mon-Eco Industries, Inc.; 55-40.

3. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
4. Service Temperature Range: Minus 20 to plus 180 deg F.
5. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.

G. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Basis of Design: Childers Products, Division of ITW; CP-10 and CP-11.
2. Manufacturers:
   a. Childers Products, Division of ITW; CP-10, CP-11.
   b. Foster Products Corporation, H. B. Fuller Company; 35-00.

2.9 SEALANTS

A. Joint Sealants: Joint Sealants for Cellular-Glass, and Polyisocyanurate Products:

1. Basis of Design: Mon-Eco Industries, Inc. "44-05".
2. Manufacturers:
   a. Childers Products, Division of ITW; "CP-76".
   b. Foster Products Corporation"30-45N".
   c. Mon-Eco Industries, Inc. "44-05".
   d. Pittsburgh Corning Corporation Pittseal "444".

B. FSK and Metal Jacket Flashing Sealants: Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 250-degree F service temperature range. Color shall be aluminum.

1. Basis of Design: Mon-Eco Industries, Inc. "44-05".
2. Manufacturers:
a. Childers Products, Division of ITW; "CP-76-8".
b. Foster Products Corporation"95-44".
c. Mon-Eco Industries, Inc. "44-05".

C. ASJ Flashing Sealants, and PVDC, and PVC Jacket Flashing Sealants. Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 250-degree F service temperature range. Color shall be white.

1. Manufacturer:
   a. Childers Products, Division of ITW; "CP-76".
   b. Foster Products Corporation"95-44".
   c. Marathon Industries, Inc.; 405.
   d. Mon-Eco Industries, Inc. "44-05".

2.10 TAPES

A. ASJ Tape: White, 3-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Basis of Design: Compac Corp. "104 and 105".
2. Manufacturers:
   a. Avery Dennison Corporation, Specialty Tapes Division "FT 2150".
   b. Compac Corp. "104 and 105".
   c. Ideal Tape Co., Inc., an American Biltrite Company; "428 AWF ASJ".
   d. Venture Tape; "1540 CW Plus, 1542 CW Plus", and "1542 CW Plus/SQ".

B. FSK Tape: Foil-face, three-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Basis of Design: Compac Corp. "110 and 111".
2. Manufacturers:
   a. Avery Dennison Corporation, Specialty Tapes Division "Fasson 0827".
   b. Compac Corp. "110 and 111".
   c. Ideal Tape Co., Inc., an American Biltrite Company; "491 AWF FSK".
   d. Venture Tape; "1525 CW Plus, 1528 CW Plus", and "1542 CW Plus/SQ".

C. PVC Tape: White, 2-inch wide, vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Basis of Design: Compac Corp. "130".
2. Manufacturers:
   a. Avery Dennison Corporation, Specialty Tapes Division "Fasson 9200".
   b. Compac Corp. "130".
   c. Ideal Tape Co., Inc., an American Biltrite Company; "370 White Pvc".
   d. Venture Tape; "1506 CW NS".
D. PVDC Tape for Indoor Applications: White, three-inch wide, vapor-retarder PVDC tape with acrylic adhesive. Manufacturer: Dow Chemical Company "Saran 540 Vapor Retarder Tape".

E. PVDC Tape for Outdoor Applications: White, three-inch wide, vapor-retarder PVDC tape with acrylic adhesive. Manufacturer: Dow Chemical Company "Saran 560 Vapor Retarder Tape".

2.11 SECUREMENTS

A. Bands:

1. Manufacturers:
   a. Childers Products.
   b. Gerrard & Co.
   c. PABCO Metals Corporation.
   d. RPR Products, Inc.

PART 3 - EXECUTION

3.1 MINIMUM INSULATION SCHEDULE

A. Fiberglass insulation shall not be used outdoors.

B. Duct insulation:

1. Supply within unconditioned spaces (above ceilings, within shafts and within mechanical rooms): R-6.
   a. 2” thick, 0.75 lb/cu.ft. mineral or glass fiber blanket.
   b. 1-1/2” thick, 2.25 lb/cu.ft. mineral or glass fiber board.

2. Supply and return outside the building envelope: R-8.
   a. 3” thick, 0.75 lb/cu.ft. mineral or glass fiber blanket.
   b. 2” thick, 2.25 lb/cu.ft. mineral or glass fiber board.

3. Return, relief, and exhaust within the building envelope, upstream of shut-off dampers: none required.
4. Outside air intake: within conditioned space, downstream of automatic isolation damper: R-6.
   a. 2” thick, 0.75 lb/cu.ft. mineral or glass fiber blanket.
   b. 1-1/2” thick, 2.25 lb/cu.ft. mineral or glass fiber board.

5. Outside air intake: within conditioned space upstream of automatic isolation damper.
   a. 6.0 lb/cu.ft. mineral or glass fiber board, R-value shall equal roof or wall values.
6. Supply, return, outside air intake, not within conditioned space in concrete or below grade: Minimum R-5.3.
   
a. 2” 7.3 lb/cu.ft. cellular glass.

C. Heating water piping, chilled water piping, steam piping and steam condensate piping:

<table>
<thead>
<tr>
<th>Fluid Operating Temperature Range and Usage (°F)</th>
<th>Insulation Conductivity</th>
<th>Nominal Pipe or Tube Size in Inches (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity Btu.in./(h∙ft²∙°F)</td>
<td>Mean Rating Temperature, °F</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>&gt;350</td>
<td>0.32 – 0.34</td>
<td>250</td>
</tr>
<tr>
<td>251 – 350</td>
<td>0.29 – 0.32</td>
<td>200</td>
</tr>
<tr>
<td>201 – 250</td>
<td>0.27 – 0.30</td>
<td>150</td>
</tr>
<tr>
<td>141 – 200</td>
<td>0.25 – 0.29</td>
<td>125</td>
</tr>
<tr>
<td>105 – 140</td>
<td>0.21 – 0.28</td>
<td>100</td>
</tr>
<tr>
<td>40 – 60</td>
<td>0.21 – 0.27</td>
<td>75</td>
</tr>
<tr>
<td>&lt;40</td>
<td>0.20 – 0.26</td>
<td>75</td>
</tr>
</tbody>
</table>

a. For piping smaller than 1 ½ inch (38 mm) and located in partitions within conditioned spaces, reduction of these thickness by 1 inch shall be permitted but not to a thickness less than 1 inch.

D. Service Schedule:

<table>
<thead>
<tr>
<th>System</th>
<th>Operating Temp. (°F)</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Pressure Steam (0-15 psig)</td>
<td>212-250</td>
<td>Glass-Fiber&lt;br&gt;Cellular Glass&lt;br&gt;Polyiso. or Phenolic&lt;br&gt;CaIum Silicate</td>
</tr>
<tr>
<td>Medium Pressure Steam (16-125 psig)</td>
<td>251-349</td>
<td>Glass-Fiber&lt;br&gt;Cellular Glass&lt;br&gt;CaIum Silicate</td>
</tr>
<tr>
<td>High Pressure Steam (126-245 psig)</td>
<td>350-399</td>
<td>Glass-Fiber&lt;br&gt;Cellular Glass&lt;br&gt;CaIum Silicate</td>
</tr>
<tr>
<td>Steam Condensate, Hot Service Drains</td>
<td>&lt;250</td>
<td>Glass-Fiber&lt;br&gt;Cellular Glass&lt;br&gt;Polyiso. or Phenolic&lt;br&gt;CaIum Silicate</td>
</tr>
</tbody>
</table>
### Notes:

1. Polyisocyanurate allowed only if it meets fire and smoke rating requirements at this thickness.
2. Use Calcium Silicate only for inserts at pipe saddles and hangers

#### E. Outdoor Cooling Tower/Condenser Water Pipe Insulation:
- Cellular Glass, Polyisocyanurate or Phenolic; 2 inch with aluminum jacket (polyisocyanurate allowed only if it meets fire and smoke rating requirements at this thickness).

#### F. Equipment:
- Provide the following on any equipment that is not factory insulated:
  1. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:
      b. Mineral-fiber board, phenolic or polyisocyanurate: 1 inches thick.
  2. Steam-to-hot-water converter insulation shall be one of the following:
      b. Mineral-fiber pipe and tank, phenolic or polyisocyanurate: 4-1/2 inches thick.
  3. Chilled-water expansion/compression tank and air separator insulation shall be one of the following:
      b. Mineral-Fiber pipe and tank: 1 inch thick.
      c. Phenolic or Polyisocyanurate: 1 inch thick.
  4. Heating-hot-water expansion/compression tank and air separator insulation shall be one of the following:
5. Steam condensate tank and receiver insulation shall be one of the following:
   a. Phenolic or polyisocyanurate: 2 inches thick.
   b. Mineral-Fiber pipe and tank: 2-1/2 inches thick and 3-lb/cu. ft. nominal density.

6. Steam flash-tank, flash-separator, and blow-off-tank insulation shall be one of the following:
   b. Mineral-fiber pipe and tank, phenolic or polyisocyanurate: 4-1/2 inches thick.

7. Chilled-water pump insulation shall be one of the following:
   b. Mineral-Fiber board: 1 inch thick.
   c. Phenolic or Polyisocyanurate: 1 inch thick.

8. Heating-hot-water pump insulation shall be one of the following:
   b. Phenolic or Polyisocyanurate: 1-1/2 inch thick.

9. Steam condensate pump and boiler feedwater pump insulation shall be the following:
   a. Phenolic or polyisocyanurate: 2 inches thick.
   b. Mineral-Fiber Board: 2-1/2 inches thick and 3-lb/cu. ft. nominal density.

10. Insulation on chilled water pumps:
    a. Fabricate metal boxes lined with insulation. Insulation shall be as indicated above for specific service. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
    b. Fabricate boxes from galvanized steel, at least 0.050 inch thick.
    c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.
    d. Box and insulation shall not be required on small fractional HP in-line pumps.
    e. A neoprene wrap is an acceptable alternative to a box.

G. Valves and pipe fittings shall be insulated as indicated below.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application. 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 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 between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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

3.3 INSULATION WORK IN GENERAL

A. General: Except as specified, material shall be installed in accordance with the recommendations of the manufacturer.

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

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

3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

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

5. Install insulation with least number of joints practical.

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

7. Do not apply insulation until surfaces to be covered have been leak tested, have had rust and scale removed, and have been cleaned, dried and inspected.

8. Insulation shall be kept dry and clean at all times.

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

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

   a. Install insulation continuously through hangers and around anchor attachments.

   b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.

   c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

   d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
e. Continue insulation vapor barrier through penetrations except where prohibited by code.

11. Continue pipe insulation through gypsum and masonry walls only if fire stopping specified in Division 07 has a UL Listed assembly that includes a jacketed insulation. Coordinate with General Contractor.

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

a. Draw jacket tight and smooth.

b. 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.

c. 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 2 inches o.c.

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

e. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.

f. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

13. All work shall be performed at ambient and equivalent temperatures as recommended by the manufacturers.

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

15. Joints shall be staggered on multi-layer insulation.

16. Do not apply insulation until heat tracing specified elsewhere in other sections of this Specification is completed and tested.

17. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces.

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

3.4 INSULATION INSTALLATION, PIPING

A. General: Pipe insulation shall be installed in strict conformance to the manufacturer’s recommendations. Pipe insulation shall be continuous and installed on all fittings and appurtenances unless specified otherwise. Installation shall be with full-length units of insulation and using a single-cut piece to complete a run. Provide jackets for all pipe insulation.

B. Insulation Installation on Straight Pipes and Tubes:

1. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.

2. Secure laps with outward clinched staples at six inches o.c, for insulation with factory-applied jackets on above ambient surfaces.

3. Do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant, for insulation with factory-applied jackets on below-ambient surfaces.
C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Polyisocyanurate Insulation:

1. All insulation shall be tightly butted and free of voids and gaps. Vapor retarder, if used, must be continuous. All fasteners and bands shall be neatly aligned.
2. In below-ambient systems, staple, rivets, screws and other fasteners capable of penetrating the vapor retarder shall not be used.
3. Install prefabricated insulation fittings on elbows, tees, and valves. Insulation at fittings shall be the same type and thickness as on straight pipe sections.
4. Lap joints of vapor retarder jacket shall be sealed using SSL tape or manufacturer’s vapor retarder tape.
5. Elbows and fittings shall be wrapped with vapor retarder tape in a spiral fashion, using a 50% overlap between successive courses of tape.

E. Unions, Flanges, Couplings, Strainers, and Valves:

1. Insulate all fittings, flanges, couplings, strainers, valves (and similar accessories) associated with an insulated piping system unless indicated otherwise.
2. Exposed Work: On exposed work, insulate to a diameter equal to insulation of adjacent piping provided a minimum of 0.75” of insulation is maintained around fittings, couplings, strainers and valves, otherwise, increase diameter.
3. Concealed Work: On concealed work, increase insulation diameter to maintain same insulation thickness as on adjacent piping. Use same material as specified for adjacent piping; fitting covers to be as specified hereinafter.
4. Adjustable and Serviceable Valves and Accessories: Where balancing valves, strainers and similar devices are adjustable or require servicing on less than a five-year cycle, provide removable insulation sections. Where valves with repackable glands and similar devices allow service, but manufacturer does not anticipate service frequency to be less than five years, make reasonable provisions to allow removal and reinstallation of the same materials with minimal effort and potential for damage.

F. Thermometer and Test Wells: Insulate test thermometer, industrial thermometer, and other test wells over their exterior length. Insulate thermometer wells protruding above finish pipe or equipment insulation. Neatly taper insulation away from top of well. Insulation on thermometer wells shall be 1-1/2” minimum thickness.

G. Insulation Support at Hangers:

1. Provide support shield and 360 degree insert between support shield and piping on piping 1-1/2” diameter and larger. Fabricate insert from heavy density insulating material suitable for the temperature. Shield shall be fabricated of 14-gauge galvanized sheet metal. Insulation shields and inserts shall be not less than the following lengths:

   1/2" to 2-1/2"   10"
2. Vapor-barrier facing of the insert shall be of the same material as the facing on the adjacent insulation. Seal inserts into the insulation with lagging adhesive for vapor seal. Where anchors are secured to insulated chilled piping, insulate anchors same as piping for a distance not less than four times insulation thickness to prevent condensation.

H. Sleeves and Wall Chases: Insulation on pipes through walls and floors shall be full size and jacketed same as adjacent insulation. Provide a metal jacket over the insulation on pipe passing through sleeves in non-fire rated walls where caulking is required.

1. Where penetrating interior walls, extend the metal jacket two inches out on either side of the wall and secure on each end with a band.

2. Provide adequate support on vertical pipe to prevent slipping.

I. Allowances for Movement: At points where pipe will move during expansion and contraction (expansion joints, Z-bends, expansion loops, etc.), clearances between the pipe and encased insulation shall be sized to permit full pipe movement without cracking or damaging insulation and casing or jacket.

J. Insulation at Mechanical Pipe Couplings: PVC insulated fitting covers shall be applied after the installation is installed. Installation shall comply with the manufacturer's recommended procedures. Connection with the pipe insulation shall be done in a neat, finished appearance, and any required vapor barrier shall be maintained.

K. Insulation Within Reach of Building Occupants: Where insulation is within reach of building occupants and visitors, insulation surfaces shall be protected by smooth sheet aluminum jacket material, 0.016" nominal thickness, lapped, banded, and installed same as above. The term “within reach” is defined as within ten feet of the floor, except for cases where there is reasonable protection (in the opinion of the A/E) offered by objects located between the insulation and the floor. This does not apply to insulation concealed within wall or ceiling construction and insulation located within equipment rooms that can be locked off from the normal building occupants.

3.5 SPECIAL PIPE INSULATION REQUIREMENTS:

A. Sterilizers, Kitchen and Laundry Equipment Piping: Provide aluminum jackets over insulation on piping that connects to equipment (where exposed to view). Insulate steam filters and provide jackets, same as for piping. Provide escutcheons at wall, ceiling or floor penetrations.

B. Cold Piping Insulation: Exposed ends of insulation shall be sealed with vapor retarding mastic installed per the manufacturer’s recommendations. Vapor seals at butt joints shall be applied at every fourth pipe section and at each fitting to isolate any water incursion.

C. Removable Insulation Sections: Installation shall conform to the following:

1. Fabricate removable insulation sections from sections of pipe insulation or block insulation as follows. Removable flexible blankets will be allowed with prior approval if adequate covering is provided. Vapor barrier must be maintained for cold surfaces.
2. When covers are made from sectional pipe insulation, extend insulation at least two times the insulation thickness over adjacent pipe insulation on each side of the component. Secure cover in place with stainless-steel hooks and wire.

3. When covers are made from block insulation, make two halves, each consisting of mitered blocks. Extend insulation at least two inches over adjacent pipe insulation on each side of the component. Fill space between the component and pipe insulation with insulating cement.

3.6 DUCTWORK AND PLENUM INSULATION INSTALLATION

A. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

B. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

C. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

1. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space three inches maximum from insulation end joints, and 16 inches o.c.

2. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and three inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

3. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

4. Do not over-compress insulation during installation.

5. Impale insulation over pins and attach speed washers.

6. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

D. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing two inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, one-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

2. Install vapor stops for ductwork and plenums operating below 50-degree F 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 three inches.

E. Overlap unfaced blankets a minimum of two inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
F. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

G. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with six-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced six inches o.c.

3.7 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Glass Fiber Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
5. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
6. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

3.8 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. Terminate insulation above roof surface and seal with joint sealant for applications requiring only indoor insulation. Install insulation for outdoor applications tightly joined to indoor insulation ends for applications requiring indoor and outdoor insulation. 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. Terminate insulation inside wall surface and seal with joint sealant for applications requiring only indoor insulation. Install insulation for outdoor applications tightly joined
to indoor insulation ends for applications requiring indoor and outdoor insulation. Seal joint with joint sealant.

3. 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 Floor, Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated floors, walls and partitions if firestop is rated for this approach. Obtain further direction from A/E if firestopping is not rated for insulated penetrations. Comply with requirements in Division 07 Section 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 Division 07 Section "Penetration Firestopping."

3.9 FIELD-APPLIED JACKET INSTALLATION

A. General: Where field-applied jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with two-inch overlap at seams and joints.
2. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with two-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.

3.10 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230700
SECTION 230816 - COMMISSIONING OF MECHANICAL SYSTEMS SUPPORT

PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Responsibilities and participation in the commissioning process shall comply with the requirements of specification Section 019113 “General Commissioning Requirements.”

B. The subcontractor representing this DIVISION OF WORK shall designate one person as the ‘Commissioning Coordinator’ (CC). The CC shall represent their company and participate as a member of the project ‘Commissioning Team’. The subcontractor shall also designate a backup person to fill the role as CC whenever the designated CC is absent. CC responsibilities are specified in Section 019113 “General Commissioning Requirements.”

C. Testing and acceptance criteria specified in this DIVISION OF WORK shall be coordinated with the approved equipment/product submittals and Commissioning Authority (CxA) Pre-Functional Check (PFC) & Functional Performance Test (FPT) documentation requirements.

D. Building components, equipment, and systems to be commissioned are listed in specification Section 019113 “General Commissioning Requirements.”

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 230816
SECTION 230900 - INSTRUMENTATION AND CONTROL 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.

B. Division 23, Section 230500, "Common Work Results for HVAC" is directly related to work included in this section. Other sections are indirectly related and shall be reviewed.

1.2 SUMMARY

A. A complete Energy Management and Control System (EMCS) shall be provided to control and/or to monitor building systems as outlined in the sequences of operation, drawings and this specification. The EMCS shall employ direct digital control (DDC).

1. Provide all software, hardware and cabling necessary for communication between operator stations, controllers, sensors, actuators and other devices.

2. Provide all miscellaneous software, wiring, parts and labor required in establishing a complete and working system that is an interoperable network capable of communicating with the existing EMCS.

1.3 APPROVED MANUFACTURERS

A. Provide HVAC control systems from the following manufacturers:

1. Heat recovery Unit HRV1: By Renewaire, as specified on drawings.
2. VRF system controls: By VRF OEM, as specified on drawings.
3. Exhaust/ventilation cooling fan controls: By unit OEM controls as specified on drawings.
4. Unit heater controls: By heater manufacturer, as specified on drawings.

1.4 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.
F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.5 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with current data within 10 seconds.
2. Graphic Refresh: Update graphic with current data within eight seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm within 45 seconds.
6. Program Execution Frequency: Run capability of applications as often as five seconds but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

   a. Space Temperature: Plus or minus one-degree F.
   b. Ducted Air Temperature: Plus or minus one-degree F.
   c. Outside Air Temperature: Plus or minus two degrees F.
   d. Temperature Differential: Plus or minus 0.25 degrees F.
   e. Relative Humidity: Plus or minus five percent.
   f. Airflow (Pressurized Spaces): Plus or minus three percent of full scale.
   g. Airflow (Measuring Stations): Plus or minus five percent of full scale.
   h. Airflow (Terminal): Plus or minus 10 percent of full scale.
   i. Air Pressure (Space): Plus or minus 0.01-inch wg.
   j. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
   k. Electrical: Plus or minus five percent of reading.

1.6 SUBMITTALS

A. Provide a complete set of reproducible control drawings using computer aided design and drafting (CADD) technology. Include the following information:

1. Show general physical arrangement of component devices installed in the panels. Indicate applicable detailed drawing reference.
2. Provide a typical schematic drawing of each control circuit.
3. Identify equipment and devices by the reference designations shown on the drawings and by unique point identification used in system software. Provide material list with or on each drawing.
4. Supply block diagrams and schematics showing riser diagrams, the layout of equipment, communication cabling, and wire type.
5. Provide system diagrams showing the general mechanical system layout with all sensors/devices of each mechanical system.
6. Supply floor plan drawings showing the location of all controlled equipment and devices used for sensing and control.

7. Provide a schematic drawing of each control circuit, complete with individual wire identifications. Typical drawings are acceptable.

8. Provide LAN truck riser diagram showing cable routing and location of all repeaters.

B. Provide sequences of operation detailing all control strategies, including initial setpoints and referencing all points by the point name used in the BAS programming. These sequences of operation shall also be provided in the record drawings.

C. Provide a complete list of equipment to be furnished, which includes a manufacturer’s catalog sheet for each item on the material list.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.

3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

4. Provide a damper schedule with one line per damper. Provide for each damper: The project TAG, the size, the model of the damper, the type and model of the actuator, and whether the damper fails open, closed, or in place.

5. Provide a valve schedule with one line per valve. Provide for each valve: The project TAG, the size, the model of the valve, the pressure rating, the model and type of the actuator, the valve Cv, and whether the valve fails open, closed, or in place.

D. Provide a detailed test plan describing the specific procedures used to complete and document the “Owner-witnessed Testing” described in the Final Acceptance requirement.

1. Test plans shall include a complete schedule for tracking each phase of the testing, e.g. zone testing by floor, fan testing by system, chiller interface testing, heating system testing, etc.

2. The vendor is required to supplement the planned work effort to meet the progress dates given in the schedule.

3. Provide printout of programming code.

4. Show initial setpoints.

5. Provide all documentation necessary to interpret programming related submittals.

E. As part of the submittal process, the vendors shall meet with representatives of the Owner’s engineering and operations divisions, giving them a thorough briefing on the BAS programming design. This briefing shall describe in detail the methods the control programmer has used to meet the requirements of the sequence of operations.

F. Submit the point-to-point (PTP) and sequence-of-operation verification test plans at least 30 days prior to the scheduled beginning of testing. PTP testing shall be part of the construction schedule.
G. Asbestos-Free Materials: The contractor shall submit asbestos-free documents (MSDS and/or, manufacturer certification,) to certify that all suspect asbestos containing materials as defined in the Puget Sound Clean Air Agency, Regulation III, Article 4 to be used in construction are asbestos-free.

H. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

1.7 QUALITY ASSURANCE

A. All materials and equipment used shall be new, standard components, regularly manufactured and not custom-designed or fabricated specifically for this project.

B. All components and software shall have been previously tested and proven in regular use. Minimum in-use requirements are 24 months for hardware and 12 months for major software (whole number revision) releases.

C. Modularity. The HVAC control system shall possess a modular architecture, permitting expansion through the addition of more distributed processing units, input/output units, sensors, actuators and operator stations.

D. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

E. 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.

F. Comply with ASHRAE 135 for DDC system components.

G. System Software: Update to latest version of software at Project completion.

H. Approval - Vendor shall submit and receive approval for all submittals including materials, floor plan, schematics and programming prior to installation.

1.8 COORDINATION

A. Coordinate location of thermostats, carbon dioxide sensors, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 28, Section 283111, "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

D. Coordinate equipment with Division 26, Section "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.
E. Coordinate equipment with Division 26, Section 260913, "Panelboards" to achieve compatibility with starter coils and annunciation devices.

F. Coordinate equipment with Division 26, Section 262419, "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

1.9 FINAL ACCEPTANCE REQUIREMENTS

A. Provide corrected documentation to show changes made to correct deficiencies discovered during commissioning tests. Reassemble manuals and drawing packages to reflect corrected documentation records.

B. Drawings and software:

1. Submit shop drawings reflecting final “as-built” condition.
   a. Provide record drawings on AutoCAD 2005. Deliver two copies of data on two CDs without compression.
   b. Provide 3 copies of reproducible record drawings.
   c. These record drawings shall accurately depict the final as-built conditions and shall be on Architectural/Mechanical backgrounds provided by the A/E.
   d. These drawings shall include accurate depiction of location of sensors and controlled equipment (motor starters, valves, chillers, dampers, AHUs, etc.)
   e. Insert one copy of applicable shop drawings, panel layout drawing, and points list at each enclosure’s documentation holder.
   f. Furnish one original set of application software on CDs. Disks shall bear the manufacturer’s label. Field copies are not acceptable. Application software includes operating system, controls application generation, graphic support, maintenance support and all other utilities provided in support of the installed system.

C. Operation and Maintenance (O&M) Manuals: Provide two paper copies of material required and five copies on CDs in MS Word format. Describe operation, maintenance and servicing requirements of the HVAC control system and associated equipment. Provide the following information in separate sections, each with an index.

1. Technical literature for all equipment, including catalog sheets, calibration, adjustments and operation instructions, and installation instructions
2. Hardware and software manuals, including information supplied by the original product developer, on the application programs and on the computers and controllers provided by vendor
3. System description and complete sequence of operation
4. Reduced size (11” x 17”) copies of record drawings
5. Input/Output (I/O) summary forms for the system, listing all connected analog and binary input and output functions and the number and types of points. Indicate spare input/output capacity
6. Control programs specific to this system
7. Completed point-to-point checkout plan used in Owner-witnessed testing, and the completed data sheets showing the results of the point-to-point testing.
D. Owner-Witnessed Testing

1. All parts of the testing described in this section are to be performed as point-to-point tests and control sequence verification. The Owner may choose to have this testing witnessed by a member of the Owner’s staff, by an independent commissioning agent, by a member of the A/E team, or otherwise.

   a. One copy of the preliminary as-built documents shall be provided to support this testing.
   b. After receipt of all system documentation by the Owner, notify Owner 10 working days before testing begins.
   c. Testing shall be performed by the manufacturer or its local representative. The procedure for the test must provide a format for documenting the results, comments, vendor repair activity, vendor’s initials, and retest witnessing. Provide data sheets with one line for each physical point on the system, and columns to record the results, dates, and initials of witnesses for both pretests and witness tests.
   d. The Contractor shall perform point-to-point pretests before the witnessed tests, and shall fill out data sheets during pretests to demonstrate successful performance prior to witnessed tests.

E. Installation verification tests:

1. Verify operation, location and identification of power sources, including circuit breakers and control power transformers.
2. Start/stop points: Issue start and stop commands from an operator station. Verify that controlled equipment responds appropriately and that the start/stop status is accurately reflected at the operator station.
3. Analog points: Analog inputs and outputs shall be verified at both extremes of their ranges and at the midpoint. Verify tight shutoff and full opening of dampers and valves.
4. Binary points: Verify that both commanded conditions (on/off, open/closed, etc.) are accurately reflected at the operator station.
5. Test fan and pump failure alarms by turning off the motor at the HOA switch and observing the run-state indication at the operator station.
6. Temperature points: Verify calibration of sensors by comparing displayed temperature values with the reading of an independent measuring device located in the same flow. Test liquid temperature sensors as installed in piping thermowells to verify effectiveness of heat conducting compound.
7. Pressure points: Verify calibration of sensors by comparing displayed pressure with the reading of an independent measuring device located in the same flow stream. Retain the services of the balancer as required to confirm readings.
8. Control valves: Verify tight shutoff by comparing water or air temperatures entering and leaving the heat transfer device.
9. Operator response and sequencing: Demonstrate that sequenced or modulated valves and dampers position accurately in response to posit multiple operators to provide simultaneous modulation of parallel dampers or valve assemblies.
10. Control signal stability, general: Demonstrate that control loops are tuned so that the output does not change until the controlled system has had time to respond to the last output signal.
11. Control signal stability, response to step input: Demonstrate that control loops are tuned so that they are stable without excessive hunting following a step input of not less than 20% of the operating/reset range of the controlled variable.
12. Control signal stability, floating point devices: Verify that minimum pulse output duration is no less than the value required to assure repositioning of the controlled device.

13. Demonstrate the capability of the controls system to execute the complete sequence of operation as given in the mechanical design documents.

14. Verify tight shut-off of all actuated control valves (for three-way valves, demonstrate capacity for 100% by-pass of coil).

F. Operator station tests:

1. Override test: Verify manual override capability for start/stop and modulated point types.
2. Control logic:
   a. Exercise all control logic packages.
   b. Check response to upset, change in setpoint.

3. Supervisory function:
   a. Verify content of time clock schedules.
   b. Verify alarm’s reporting capabilities.

4. Failure modes:
   a. Verify all stand-alone operation by disconnecting communication lines between stand-alone control units and verifying continued operation.
   b. Disconnect and reconnect controller power to confirm proper recovery from power failure (sample).

G. Other software tests:

1. Trend logging
2. Report generation
3. Remote access
4. Test the ability of the control system to automatically restart all of the connected systems following a power restoration and fire alarm recovery.

1.10 SERVICE AND GUARANTEE

A. The complete control system shall be warranted to be free of defects in manufacturing, workmanship and materials for one year. Temperature sensor accuracy shall be warranted for three years. Software and documentation shall be revised to reflect system changes required to meet warranty obligations.

B. During the warranty period, provide a 24-hour emergency service telephone number where a qualified service technician, familiar with the installed system, may be reached.

   1. This technician shall have the capability of remote communication with the control system for troubleshooting and program alterations.
   2. The vendor shall pay all costs to provide communications for remote access.
3. A fully equipped, qualified repair technician shall be at the job site within four hours of a request for emergency service.

C. All replacement parts must be available on site within 48 hours during the term of the warranty.

D. Provide free of charge during the warranty period four DDC software sequence modifications (up to 24 hours engineering time) as instructed by the Owner. Modification shall be in software only.

1.11 POST-INSTALLATION TRAINING AND MATERIALS

A. The manufacturer and control contractor shall train operating personnel (FOMs) in the operation and maintenance of the system as follows:

1. The controls subcontractor shall provide the Owner's system operators complete training for proper control of the system under all modes of operation. These modes shall include but not be limited to summer/winter, energy management and alarm event sequences. The training shall be conducted during normal working hours, Monday through Friday at the job site. Training shall consist of both classroom and hands-on training. Provide a minimum of 16 hours of on-site training for a total of three people. Provide each trainee with a copy of the sequence of operations and the graphics during each training session. Training will be refined based on the successful bidder and may address the following subjects:

a. Sensor/actuator operation.
b. System architecture and basic theory of operation.
c. Operator level (password level 1) interface to system for password access, alarm handling, point addressing, manual commands and statistical data acquisition.
d. Program level (password level two) operation for command control and definition of energy management parameters.
e. Configuration level (password level three) for all database entry and modification.
f. Review of sequence of operations.
g. System troubleshooting.
h. Emergency service support.
i. Fire alarm interface.
j. System restart after power failure.
k. Replacement procedures of each system component.
l. Calibration and initialization procedures.
m. Regeneration procedures on all installed programming at operator’s control stations.

2. Provide one each of the following:

a. Complete reference materials (manuals) that would be used by a factory trained master technician
b. Test instruments, and software manufactured or modified by the manufacturer for use in the installation, troubleshooting, and repairs of installed devices. Include unique portable test terminal, test boxes, circuit card extenders, calibration modules, etc.
3. The Owner will be allowed to video tape any or all of the training sessions.

B. Provide all of the training and materials that a control contractor service employee would receive in order to become a Master Technician. Training and materials will be provided for three Owner representatives on separate schedules. Provide a complete description of this training with the submittals. Include the cost of training, travel, lodging and transportation between lodging, airport and training location.

1.12 SYSTEM COMMISSIONING

A. Provide assistance, staff and materials to support the commissioning activities.

1. This includes all testing apparatus in use by the BAS contractor to test and calibrate or verify calibration of the control system.
2. Assistance includes but is not limited to reviewing test procedures and providing software enhancements to accommodate testing methods.

B. Provide staff and materials to support the point-to-point testing, also referred to as Owner-witnessed Testing and described under Final Acceptance Requirements.

C. Operate the control system for any commissioning tests specified in other specification sections.

1.13 SEQUENCE OF OPERATION

A. See drawing M-801.

PART 2 - PRODUCTS

2.1 GENERAL

A. Provide as required for a complete and operating building automation system, all software, hardware, input/output devices, wiring and control power not shown in electrical bid documents, actuated dampers, actuated valves, actuators, operation and maintenance training, special maintenance tools and aids, supervision of labor, and warranty.

B. The system shall be built only of standard components kept in stock by the supplier.

1. All replacement parts shall be available on site within 48 hours.
2. The components shall not require customizing other than setting jumpers and switches, or adding firmware or software modules, or on-site software programming to do required functions.

C. System display should meet the following requirements:

1. The system is to be fully menu-driven.
2. All system titles, prompts, and instructions are to be in the English language.
3. All entries to be in natural units, i.e., a setpoint value shall be entered in its actual control unit of value, such as 74°F.
4. The primary means of information display and system management shall be by graphic display. Use the same style of display as is currently used throughout the facility.
5. Each display will contain comment sections to indicate area served (if area-specific) and also contain a graphical presentation for all other interlocked systems.

2.2 BASIC SYSTEM FEATURES

A. Zone-by-zone control of space temperature, usage scheduling, and equipment failure reporting (A zone is the area served by one HVAC terminal unit, fan coil, heat pump, air terminal, etc.)

B. For all controllers and other devices that do not automatically and immediately resume normal operation after loss of power and then restoration of power, provide Werner Electric Stabiline UPS (Uninterruptable Power Supply) model SW1500 (or approved equal having five-year battery life and battery hot swappable capability) for all cabinets having a mounting area over 120 square inches and containing controllers. These cabinets shall be provided with a fused duplex receptacle to be used as a source for UPS power. Cabinet shall draw power from the UPS. Provide shelf for UPS.

C. All control power shall be provided from 120 VAC emergency power sources located in the “low voltage” closets on each floor and in the mechanical rooms.

D. Tamper-proof room wall mounted sensors installed with Allen, Bristol or similar hardware with local temperature setpoint adjustment (limited range). The maximum allowed temperature range shall be set from an operator’s station. Program the local control ranges as follows:
   1. Standard thermostats - 70°F to 75°F
   2. OR thermostats - 68°F to 75°F
   3. Mechanical and electrical rooms - 50°F to 85°F

E. Space temperature control in specifically identified locations will use return/exhaust duct mounted sensors and setpoint will be adjusted with computer interface.

F. Individually assignable priority password security system to prevent unauthorized use. Provide at least four levels including the following: Information only, change of setpoint & ON/OFF, programmer, and a fourth master level for assigning appropriate local access.

G. Equipment monitoring and alarm function including information for diagnosing equipment problems.
   1. All system points shall be programmed to report alarm conditions by fully expanded point names that are tailored and specific to this project.
   2. Assign alarm limits at 10% above highest expected level and at 10% below lowest expected level (subject to control sequence design) or as requested by Owner.
   3. Interlock all alarm points to system status so as to lock out alarms when the system is not operational by schedule or operator command.

H. Auto-restart, without operator intervention, the operator stations and all controlled equipment to the control state that would be in effect if the power failure or fire alarm event had not
occurred. Start/stop outputs shall continue to command the affected device while motor power is unavailable and allow for equipment restart, as previously commanded or scheduled, upon restoration of motor power.

I. Equipment run-time totalization of motor driven equipment.

J. Interactive displays of all input and output points: As a minimum, each of 200 screens on the monitor shall be able to display 25 interactive points and custom text.

K. Operator shall be able to, through keyboard interface, disable any control logic for any output or setpoint, temporarily substitute the value for any input/output, and introduce a different value or state for all inputs, outputs and setpoints.

L. Individual controllers shall be programmed with nonvolatile stand-alone control logic necessary to maintain appropriate HVAC equipment operation. While in temporary stand-alone mode, energy efficiency can be sacrificed to maintain temperature control and operational conditions that will not damage equipment or compromise health and safety.

M. Controllers shall, upon loss of valid programming, be capable of requesting and receiving a programming download of all required program code from the system management server.

N. Owner personnel shall be able to create and modify control software in any facility computer utilizing menu-driven programming. Owner personnel shall be able to store the programming on a removable computer disk and preprogram a nonvolatile, transportable memory storage device, which can be used for replacement of the programming in system controllers.

2.3 SYSTEM ARCHITECTURE

A. The BAS shall consist of a network of controllers providing full stand-alone operation of the building. The controllers shall contain the necessary programming to accomplish the sequence of operations for building control.

B. Controllers shall normally execute the control strategy to use peer-to-peer communication capabilities. Upon loss of communication, the stand-alone control unit shall be able to execute its own stand-alone programming. This distribution of control authority is mandated so that the lost communications capability shall not cause a complete loss of control for affected systems.

C. Operator station shall not be necessary to sustain building operation.

D. All EMCS equipment installed in this project shall be interoperable to interface with the existing campus EMCS. All control products provided for this project shall comprise a BACnet internetwork.

E. The Contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the internetwork.

F. All controllers shall have a communication port for connections with the operator interfaces using the BACnet Data Link/Physical layer protocol.
G. Communication services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:

1. Connection of an operator interface device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.

2. All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to a object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform internetwork value passing.

H. Dedicated Controllers: All sensing points and controlled outputs associated with a sub-system or piece of equipment shall be wired to and processed within one controller. A sub-system is defined as a group of equipment items that are directly controlled together, such as the components associated with an air handler. A “reset” signal may come from another subsystem controller. When supply terminal units are to be tracked by an exhaust terminal unit, all supply and exhaust monitoring and control points shall be processed by the same controller.

2.4 GRAPHICS

A. General: Provide complete graphics for all systems. Graphic completeness, appearance and quality shall be the best available from the approved manufacturer. All system shall be diagrammed in the graphics with measured values indicated at the appropriate location on the diagrammatic graphic. Setpoint, on-off-auto and similar adjustable shall be at the appropriate location on the diagrammatic graphic.

B. Graphic display requirements:

1. Provide a Microsoft Windows-based software package for the preparation of system graphics.
2. Include with this software a library of HVAC symbols such as fans, pumps, chillers, etc.
3. This section establishes standards for graphic displays as follows:
   a. All operator stations shall be programmed to display dynamic color graphic representations of the mechanical systems and floor areas for which this system has control.
   b. Systems to be displayed include the air handlers (including all monitored and controlled components), air terminal units, fans, chillers and towers, heat converters and exchangers, pumping systems and similar mechanical devices.
   c. Show the mechanical equipment components on a single graphic. Example: Chilled and condenser water pumps, cooling towers, chillers, differential pressure control valves, etc.
   d. Displays shall automatically update with current real time data.
   e. Room floor plan displays are required and shall indicate the approximate positions of controlled mechanical system elements.
f. All displays shall show real time data to include temperatures, actuator positions, and motor run status.
g. All system input, output and setpoint points shall be displayed on an appropriate graphic.

2.5 DDC EQUIPMENT

A. OPERATOR STATIONS

1. Local Access: Operator interface with the installed EMCS equipment and the entire campus BAS shall be performed with portable computers and desktop computers using site licensed software.

2. WEB Access: It shall be possible to interface with the EMCS from remote computers equipped with Microsoft Internet Explorer (web browser) via the Internet.
   a. Operators shall be able to access information through user interfaces at the application controller and the plant controller levels, as well as at the master display.
   b. System shall be an open, interoperable system supporting LonWorks®, BACnet® and/or other protocols.

3. Operator interface with the EMCS includes the ability to operate and program all campus EMCS equipment. The ability to look, adjust/override and program will be controlled using access levels.

4. Overall management of the EMCS, storage of programs, data, trends, access control, graphics.

5. Application Software:
   a. I/O capability from operator station.
   b. System security for each operator via software password and access levels.
   c. Automatic system diagnostics; monitor system and report failures.
   d. Database creation and support.
   e. Automatic and manual database save and restore.
   f. Dynamic color graphic displays with up to 10 screen displays at once.
   g. Custom graphics generation and graphics library of HVAC equipment and symbols.
   h. Alarm processing, messages, and reactions.
   i. Trend logs retrievable in spreadsheets and database programs.
   j. Alarm and event processing.
   k. Object and property status and control.
   l. Automatic restart of field equipment on restoration of power.
   m. Data collection, reports, and logs. Include standard reports for the following:
      1) Current values of all objects.
      2) Current alarm summary.
      3) Disabled objects.
      4) Alarm lockout objects.
      5) Logs.
   n. Custom report development.
6. Custom Application Software:
   a. English language oriented.
   b. Full-screen character editor/programming environment.
   c. Allow development of independently executing program modules with debugging/simulation capability.
   d. Support conditional statements.
   e. Support floating-point arithmetic with mathematic functions.
   f. Contains predefined time variables.

B. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
   d. Software applications, scheduling, and alarm processing.
   e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:
   a. Coordinate

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

C. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
   a. Global communications.
   b. Discrete/digital, analog, and pulse I/O.
   c. Monitoring, controlling, or addressing data points.
3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

D. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (four to 20 Ma).
7. Universal I/Os: Provide software selectable binary or analog outputs.

E. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined one percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least three seconds without failure.

F. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.6 UNITARY CONTROLLERS

A. Each controller shall operate as part of the control system and as an independent unit when not in communication with other controllers or an operator station. Global controllers shall be able to share Global information on a peer-to-peer basis without relying on an operator station.

B. It shall be possible to define control strategies at each controller from any operator station. Each controller shall be able to interface directly with an operator station.

C. Each controller shall include its own microprocessor, power supply, and, if necessary, battery with automatic charger. Upon loss of system power, the controller memory shall be maintained for a minimum of 72 hours with no external source of power. Upon restoration of system power, the control unit shall resume full operation without operator intervention.
D. Provide control programming logic at each controller for proportional and/or proportional plus integral control capabilities as necessary to assure complete and stable control of each controlled variable.

E. Each controller shall maintain and perform its own stand-alone control strategy upon communications failure. The controller stand-alone control program shall be adequate to maintain the basic control function and provide protection from inappropriate equipment operation. The controller shall retain its programming during a power failure and resume operation without program reloading from another device.

F. The controllers shall be powered by 24 VAC.

G. Each controller shall be isolated (optically or by other means) from communication trunk and have fuse or overload protection.

H. The controller point monitoring and control capabilities shall include but not be limited to the following:
   1. Binary inputs (contact closures)
   2. Analog inputs (use only resistive, 0-10 volt, and 4-20 ma. inputs; provide A/D conversion of 10 bits, minimum)
   3. Binary output (start/stop or latching and momentary contacts)
   4. Floating point control
   5. Analog outputs (must include 4-20 ma. @ 10 VDC minimum, 0 -10 VDC; provide A/D conversion of 12 bits, minimum).
   6. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

2.7 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
   1. Alarm Condition: Indicating light flashes and horn sounds.
   2. Acknowledge Switch: Horn is silent and indicating light is steady.
   3. Second Alarm: Horn sounds and indicating light is steady.
   4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
   5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.8 ALARM PROGRAM

A. For each alarm input, provide the following assignable alarm responses:
1. Display English language point description in addition to system point identification.
2. Print out alarm description and operator-created alarm message.
3. Require acknowledgment by operator and print occurrence if directed by Owner.

2.9 LOGS

A. Trend log: As a minimum, provide capacity for 50 trend logs. Provide for review of data on monitor and printer. Each trend log shall have assignable start/stop times/dates.

B. Current alarm log: Display all points currently in alarm. Operator activity log: Record operator activity by operator account identification and work performed during a minimum of the last 10 log-in sessions or last 20 commands.

2.10 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70-degree F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.

2.11 FAILURE MODE

A. Upon failure of any global controller, the operator station shall display off-line occurrence for each affected point, and provide communication verification to each controller for each I/O channel.

B. In the event of communication failure, controller shall continue to operate equipment using appropriate backup values for missing global information. If sensor information is necessary for proper stand-alone function, then that sensor shall be attached directly to the appropriate controller. Provide failure mode programming to accomplish safe operation of equipment in case of communications failure on local trunk.

C. Upon return of primary power after a power failure of up to 72 hours, the system shall automatically return to completely normal operation with no action required from operating personnel.
D. Unless otherwise indicated in the design documents, provide the following failure modes, (that is, the position that the controlled device attains under failure due to loss of power, loss of air pressure, or loss of communications) for valves and dampers:

1. All Fan cooling water valves shall fail closed.
2. All central cooling water differential pressure control valves shall fail closed.
3. All fan exhaust air and outside air dampers shall fail closed.
4. All fan recirculation dampers shall fail open.
5. Zone-level air terminal unit dampers may fail in place.

2.12 ENERGY REDUCTION AND SPECIAL OPERATION SOFTWARE

A. The system shall be designed to control energy-consuming loads. Provide engineering, consulting, and programming to develop and set up the following energy reduction software:

1. Time schedules: Software should provide at least 16-time schedules. Each schedule is to be an 8-day type, capable of six entries minimum per day. Time program shall provide ON/OFF commands and reset SETPOINT capabilities.
2. Holiday time programs: Provide a holiday time schedule capability.
3. Optimal start/stop: Provide the ability to optimize start/stop times to attain and maintain temperature setpoint only during occupied times. The system shall be self tuning, with compensation for weekends and holidays.
4. Setpoint reset: Provide a means of automatically resetting heating water, chilled water and ventilation air temperatures, volumes and pressures.
5. Provide a program to automatically restart all DDC controlled equipment upon the resumption of power or return from fire alarm condition. Equipment shall be restarted according to a prearranged, prioritized and staggered restart schedule.
6. For loads that have been turned off at the Motor Control Center, either by positioning of the HOA switch or the line disconnect; provide a restart strategy that automatically restarts load upon the reset of switches to their normal on-line positions.
7. Provide capability to adjust the setpoints of main mechanical systems from an operator station using simple ‘point and click’ command windows.

2.13 ELECTRONIC SENSORS

A. Temperature sensors:

1. Sensors shall be completely precalibrated with no electrical adjustments or calibration required for standard installation conditions.
2. The temperature displayed at an operator station shall be accurate to within 1° F. This accuracy shall be warranted (parts and labor) for a minimum of three years.
3. Wall-mounted sensors shall be tamperproof. Wall mounted sensors for zone controls shall provide jack for operations laptop connection. That connection shall allow communication with system for monitoring and adjusting at least the zone-level equipment serving that zone. Wall sensors shall include temperature readout and shall provide basic control sequence diagnostic and reset features and local setpoint adjust and after-hours override. Manufacturer Invensys Micronet.
4. Freeze protection sensors shall be non-averaging.
5. Thermowells shall be bronze, brass, or stainless steel with 1-inch NPT threads.
6. Install piping temperature sensors adjacent to temperature gauge or test port.
   a. Use heat-conducting compound in thermowells.
   b. Strap-on fluid temperature sensors will not be allowed.

7. Mount outside air sensors inside the outside air intake as to avoid solar influence and
directly sense the average temperature of the air entering the air handling unit(s).

B. Air velocity transmitter: Shall provide air velocity information independent of the effects of
static pressure. Transmitter shall operate at rated accuracy from 0º F to 120º F. The minimum
accuracy of displayed value at an operator station shall be 95% through the range of 20% to
100% of sensed airflow, with a drift rate no greater than one percent per year. The proportional
output shall be 4 to 20 ma.

C. Differential and static pressure transmitter: Transmitter shall operate from 50% of minimum to
150% of maximum anticipated pressure. The maximum error of displayed value at an operator
station shall be 2% through the range of 20% to 150% of the intended maximum setpoint. Minimum pressure tolerance shall be 150% of the maximum pressure expected in normal
operation. The maximum drift rate shall be no greater than one percent per year. The
proportional output shall be 4 to 20 ma. Provide designed pressure pitot sensor Dwyer type A-
301/A 302 or approved equal.

D. Current sensors shall convert AC to proportional DC (4 to 20 ma). Response time: 300
milliseconds to 99% of final value. Manufacturer: Neilson-Kuljian or approved equal.
Controls will be programmed to indicate equipment failure if motor current goes above or
below normal conditions.

E. Averaging elements shall be mounted so as to cross a minimum of 80% of the plenum width
and shall be located to provide an indication of temperature within +/- 1º F. Provide support at
36 inches maximum such that there will be no metal to metal contact between the sensing
element and other equipment.

F. Outside air sensors shall be a waterproof assembly protected from solar radiation. Span shall
cover the range of 0º F to 100º F or better and not exceed a 150º F span. Typically, mount
sensor inside an outside air intake that draws air 24/7.

G. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected
input, and temperature compensated.
   a. Accuracy: Two percent of full scale with repeatability of 0.5 percent.
   b. Output: 4 to 20 mA.
   c. Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
   d. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).
   e. Manufacturer:
      1) Tek-air Systems Inc., Ultra low series
      2) Setra Systems
      3) Veltron
4) Modus “low flow T” series
5) Ultratech Inc.

2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential. Manufacturer:
   a. Tek-air Systems Inc., Ultra low series
   b. Veltron
   c. Modus ’low flow T’ series
   d. Ultratech Inc
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.14 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.
B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.
C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
D. Voltage Transmitter: Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and one percent full-scale accuracy.
E. Power Monitor: Three-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

2.15 THERMOSTATS

A. Thermostats shall be low-voltage, thermistor sensor, touch screen operated, with 55 to 85-degree F set-point range, minimum. Thermostats shall be programmed so the user can adjust
temperature higher or lower a pre-determined range (coordinate range with owner). A 5-degree deadband between heating and cooling shall be programmed.

2.16 GAS DETECTION EQUIPMENT

A. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130-degree F and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting. Manufacturer: Ventostat model 8001.

B. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.17 ELECTRONIC AIRFLOW MEASUREMENT STATIONS:

A. Ebtron Model GTC116 or approved equal. Thermal dispersion airflow measurement. UL listed, airflow accuracy +/- 2% of reading, 6063 gold anodized aluminum probe, 304 ss brackets, RS-485 output with BACnet MS/TP.

B. General

1. Provide one airflow measurement device (AMD) for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.

2. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.

   a. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.

3. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.

   a. Actual airflow rate calculations shall have the capability of being adjusted automatically by the transmitter for altitudes other than sea level.

4. Temperature measurement shall be field configurable to determine the velocity weighted temperate or simple arithmetic average temperature.

C. Sensor Probes

1. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube [insert 316 stainless steel tube in lieu of 6063 aluminum alloy tube, when required].

2. Sensor probe mounting brackets shall be constructed of 304 stainless steel.

3. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.

   a. PVC jacketed internal wiring is not acceptable.

4. Probe internal wiring connections shall consist of solder joints and spot welds.
a. Connectors of any type within the probe are not acceptable.
b. Printed circuit boards within the probe are not acceptable.

5. Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.

6. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392°F and continuous and direct UV exposure.
   a. Plenum rated PVC jacket cables are not acceptable.

7. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.

8. Each sensor probe shall contain one or more independently wired sensing nodes.

9. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.

10. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.
    a. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.

11. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.

12. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.

13. The number of independent sensor nodes provided shall be as follows:

<table>
<thead>
<tr>
<th>Area ft²</th>
<th># Sensor Nodes</th>
<th>Area ft²</th>
<th># Sensor Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 0.5</td>
<td>1</td>
<td>&gt; 4 &amp; ≤ 8</td>
<td>8</td>
</tr>
<tr>
<td>&gt; 0.5 &amp; ≤ 1</td>
<td>2</td>
<td>&gt; 8 &amp; ≤ 12</td>
<td>12</td>
</tr>
<tr>
<td>&gt; 1 &amp; ≤ 2</td>
<td>4</td>
<td>&gt; 12 &amp; ≤ 14</td>
<td>14</td>
</tr>
<tr>
<td>&gt; 2 &amp; ≤ 4</td>
<td>6</td>
<td>&gt; 14</td>
<td>16</td>
</tr>
</tbody>
</table>

a. A total of 4 probes shall be required for openings with an aspect ratio ≤ 1.5 and with an area ≥ 25 ft².

D. Transmitter

1. A remotely located microprocessor-based transmitter shall be provided for each measurement location.

2. The transmitter shall be comprised of a main circuit board and interchangeable interface card.

3. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.

4. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.

5. All receptacle plug pins shall be gold plated.

6. The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes.
a. Separate integration buffers shall be provided for display airflow output, airflow
signal output (analog and network) and individual sensor output (IR-interface).

7. The transmitter shall be capable of providing a high and/or low airflow alarm.
8. The transmitter shall be capable of identifying an AMD malfunction via the system status
alarm and ignore any sensor node that is in a fault condition.
9. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
   a. The airflow rate, temperature, airflow alarm and system status alarm shall be
      visible on the display.
10. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA),
    scalable, isolated and over-current protected analog output signals and [select one or both
    of the following] one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU)
    network connection; or one isolated RS-485 (field selectable BACnet MS/TP or Modbus
    TRU) network connection; or one isolated Ethernet (simultaneously supported BACnet
    Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection.
11. Analog output signals shall provide the total airflow rate and be field configurable to
    output one of the following:
       a. temperature
       b. airflow alarm; or
       c. system status alarm
12. Network communications shall provide the average airflow rate, temperature, airflow
    alarm, system status alarm, individual sensor node airflow rates and individual sensor
    node temperatures.
13. Provide an infra-red I/O card mounted on the transmitter PCB for communication to a
    handheld retrieval device that can download individual sensor node airflow and
    temperature data in real time.
14. The transmitter shall be powered by 24 VAC and use a switching power supply that is
    over-current and over-voltage protected.
15. The transmitter shall use a “watchdog” timer circuit to ensure continuous operation in the
    event of brown-out and/or power failure.

E. Performance

1. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating
   range of 0 to 5,000 FPM.
   a. Accuracy shall include the combined uncertainty of the sensor nodes and
      transmitter.
   b. Devices whose overall accuracy is based on individual accuracy specifications of
      the sensor probes and transmitter shall demonstrate compliance with this
      requirement over the entire operating range.

2. Each sensing node shall have a temperature accuracy of ±0.15°F over an operating range
   of -20°F to 160°F.

F. Listings and Certifications
1. The AMD shall be UL873 Listed as an assembly.
   a. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.

2. The AMD shall be BTL Listed.

3. The AMD shall carry the CE Mark for European Union Shipments.

2.18 ACTUATORS

A. Actuator type: Electronic actuators shall be used for all water control valves and air dampers.

B. Electronic actuators shall be Belimo, Delta, or approved equal selected from the vendor's standard product line.

1. Sized for torque required for damper seal at load conditions.

2. All electronic actuators shall be powered by 24 VAC (smoke damper are powered by 120 volts as per specification 233300).

3. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

4. Proportional electronic actuators shall use 0 to 10 VDC, 4 to 20 ma. or floating-point control.

5. Floating point actuators shall have position indicated by potentiometer so control system will know exact position at all times.


7. Multiple electronic actuators may be powered by one separately fused 24 VAC transformer, providing the transformer size does not exceed 100 VA.

8. No more than two electronic actuators may drive a common shaft.

9. All electronic actuators shall have field manual positioning capability to allow manual positioning of valve or damper in absence of control power.

10. Two integral built-in auxiliary end switches.

11. Actuator shall have positioning feedback.

C. Actuators shall be capable of providing 150% of the minimum valve or damper manufacturer’s published torque requirements for complete shutoff.

D. Actuators shall ‘Fail in Last Position’ unless otherwise noted.

E. Valve actuators shall have clutch and manual positioning handle/wheel at all locations where a separate isolation valve is not provided immediately adjacent to the controlled valve.

2.19 CONTROL VALVES

A. Control valves shall be selected to meet CV and pressure requirements.

1. Two-way pressure independent water control valves shall be sized for a pressure drop of approximately 3 psi. Higher pressure drop shall be provided if allowed or directed by the A/E (during shop drawing review) where branch pressure to a controlled equipment is felt to be significantly more than the equipment pressure drop.
2. Three-way water control valves shall be sized for a pressure drop of approximately 2.5 psi.
3. Steam valves for equipment having condensate draining to near-atmospheric pressure shall be sized for a pressure drop of approximately 50% of the normal steam supply pressure.
4. Valve body and actuator selection shall be sufficient to handle system pressure, and shall close against the system differential pressures.
5. Valve service rating shall be 125 psig. or greater.
6. The shafts to which the actuators are coupled shall be square or hexagonal or round with one side flattened to insure tight coupling.
7. Install valves in the orientation recommended, or stated as preferred, in manufacturer’s literature.

B. Provide valves with rotating control stems except where “lift and lay” valves are specifically identified. Use the following valves unless they are unsuited for a specific application:

1. Use Belimo or Delta characterized ball valves with actuators for sizes ranging from ¼” to 2” full port. Where valves are for open-close application only, the “characterized” feature shall not be provided, provide full port size.
2. Zone valves: Valves shall be constructed with a cast brass body and stainless-steel balls. The valve shall provide for 100% shut-off and silent operation.

C. Use butterfly valves when characterized ball valves do not provide necessary CV. Butterfly valves with disks attached to the stem with screws, bolts or rivets are not acceptable. Use Demco, Victaulic or approved equal. Butterfly Valves: 150-psig maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

D. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig and 250-degree F operating conditions.
2. Thermostatic Operator: Liquid filled remote sensor with integral adjustable dial.

2.20 DAMPERS

A. See Section 233300 - Air Duct Accessories.

2.21 Variable Frequency Drives (VFDs)

A. VFDs for division 23 equipment shall be provided by the controls system subcontractor as per section 230915.

B. Division 26 contractor shall install field mounted VFDs and provide power wiring to the VFDs and from the VFDs to their controlled motors.

C. The controls system subcontractor shall provide control wiring for VFDs. The controls system subcontractor shall provide VFDs for packaged and custom air handling units to the respective manufacturers specified in Section(s) [237000, 237012] for installation and wiring at the
Division 26 contractor shall provide power to factory mounted VFDs once they are installed in the field.

2.22 ENCLOSURES

A. All enclosures to be NEMA 1, unless otherwise required for intended service. All controls and instruments shall be logically assembled at one or more panels, have hinged doors and be marked with engraved melamine labels.

B. All enclosures used as a mounting site for control devices shall also contain a documentation holder located on the inside of the door.

C. All enclosures shall be provided with locks.

D. Label each equipment panel furnished with 120 VAC power with power source label showing identification of power panel and breaker.

2.23 WIRING AND CONDUIT

A. Install wiring and conduit in accordance with Division 26 requirements.

B. Minimum wire size shall be based on the manufacturer’s recommendations based on the specific application. Single conductor wire insulation shall be THHN. All wires shall be sized in accordance with the NEC for the load serviced. A single conductor shall not be used for more than one leg of an input or output device circuit (no “common” conductors) unless approved by Owner.

C. All wiring shall be stranded. Exceptions will be made for wiring used in preassembled factory crimped cables, 20 g and smaller, where connectors provide support to the insulated cable jacket at the point of connection.

D. All low voltage energy limited wiring (except 24 VAC power), installed in open tray or installed as open wiring, shall be in jacketed cables dedicated to individual devices.

E. Junction box covers shall be labeled “DDC” or show the vendor logo.

F. Splicing shall be minimized and shall be done only in accessible outlet, junction, or cabinet boxes that are clearly shown on the “as-built” record drawings. Splicing shall be made with 3M “Scotchloc” spring connectors with steel cap and PVC insulation, Thomas & Betts, or a crimp on butt-splice, or approved equal. When splicing is necessary, the insulation colors shall match and the conductors shall be mechanically secured to each other so that no stress is applied to the splice. Splicing of long runs shall be accomplished by means of a fully insulated crimped barrel connector.

G. Wire pulls by powered mechanical means will not be permitted. Conduit shall be cleaned of foreign material just before pulling the wire or cable. Lubricants shall be compounds specifically prepared for cable pulling and shall not contain petroleum or other products that will affect cable insulation.
H. Wire that has scrapes, nicks, gouges, or crushed insulation shall not be used and shall be removed when present.

I. Groups of conductors, where installed in cabinets and wire trays, shall be neatly grouped with wire ties or equal.

J. All wiring contained in metal wireways shall be in wireways dedicated to low voltage service.

K. Low voltage energy-limited wiring shall not be run in the same wireways with, or closely parallel to, high voltage or switched power wiring. Interposing relays shall be used for all switched power loads and shall be located so that the switched power conductors do not run in the same wireway as the interposing relay coil power or any other energy-limited low voltage conductors.

L. All wire shall be new and brought on the jobsite in original packages bearing Underwriter’s label and the date of manufacture.

M. Aluminum wire is prohibited.

N. No conduit shall be filled so that the maximum bundled cross-sectional dimension exceeds 40% of conduit inside diameter. No raceway shall be filled to more than 40% and maximum fill for “wiremold” (surface raceway) shall be 20%.

O. No wire run or circuit shall be longer than 80% of the maximum allowable length or power consumption for the wire size and application. No output circuit shall exceed 80% of the maximum load capacity specified by the manufacturer.

P. Wiring and conduit shall comply with Division 26 specifications.

1. The basic wiring method shall be in conduit unless otherwise permitted in this section.
2. Where conduit direct connection is not possible, all permitted open wiring shall be plenum rated.
3. Permitted open wiring is limited to the following applications:
   a. Wiring from a zone airflow control unit to a nearby temperature sensor not to exceed 50 feet
   b. Wiring from a zone airflow terminal control unit to a nearby water control valve not to exceed six feet

Q. Wiring from any controller to a device which has otherwise been approved for installation and cannot accept conduit connection shall meet the following requirements:

1. Conduit shall be used to within 12 inches of the device.
2. Install in wireway all trunk communication wiring between the operator station and the controllers, and between controllers. Open wiring is not otherwise permitted.

R. Conduits shall be provided with appropriate bushings and end fittings to protect cabling from sharp conduit edges.
S. Conduit size shall be ¾-inch minimum for all wiring groups consisting of six or more conductors. NEC requirements shall apply as though conductors were used to their full current carrying and thermal capacity.

T. Wireway runs shall be level, plumb, parallel or perpendicular to walls, pipes and sides of openings. Wireways shall follow the contours of the support surface. Passageways for access and servicing shall not be blocked.

U. All wiring between global controllers and trunk, N2 and LAN cables longer than 300 feet shall be 100% backed up with spare conductors.

V. All conductors that become bundled or pass from an enclosure shall be identified with typed or machine lettered labels, Briade or approved equal. Tag numbers shall agree with wire numbers assigned on wiring diagrams and the installation drawings.

W. Wires shall be labeled with mechanically prepared labels at their connection point to each apparatus point of connection.

X. UL/ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls and for final connection to equipment.

Y. Open wiring, when permitted, shall be installed in compliance with WAC 296-46-725 with reference to NEC 336-15 and shall also be installed as follows:

1. All open wiring that penetrates through walls and crosses structural ceilings shall do so within 18 inches of the structural ceiling surface.
2. Wiring shall be attached to vertical supports at attachment points prepared by a protective wrap of electrical tape around the support. This wrap shall create a surface free of sharp edges.
3. Absolutely no wire is to be attached to pipe work or conduit of any kind.
4. Wire ties, if used, shall be trimmed so as to reduce sharp edges.
5. The vendor shall provide required cabling attachment points for control’s use if the ceiling structure does not provide acceptable attachment points.

2.24 CONTROL RELAYS

A. Panel relays shall be plug-in type with contacts rated at twice the amperage rating of circuit requirements: Minimum temperature range –25° C to +70° C. Enclosure: Clear dust cover and shock resistant, rated for minimum of 2.5 million mechanical operations and 100,000 electrical operations at full load.

B. Remote/interposing relays shall be used for all remote switched loads.

1. They shall be housed in a NEMA-rated enclosure. Where two or more relays are mounted in the same enclosure, provide a hinged cover.
2. Besides meeting panel relay requirements, relays shall have 24 VDC coils and form C dry contacts with a minimum rating of 5 amperes @ 240 VAC.
3. Relays controlling inductive loads shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.
2.25 TRANSFORMERS

A. 120V AC to 24V AC transformers shall be supplied to provide control voltage to the control system. The incoming 120V AC power shall be fused. Transformers shall be supplied with suitable mounting plates and mounted in separate electrical panel boxes with hinged covers adjacent to control system panels.

2.26 SPARE PARTS

A. Replacement Materials: Provide one replacement for each unique controller, damper motor, valve motor, thermostat, relay, etc.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS.

A. General: All work under this section shall be a subcontract by an authorized agent of the manufacturer.

B. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

C. Notations at Instruments: A typewritten notation shall be provided at each instrument stating its use; at thermostats, the proper setting. In finished spaces these notations shall be secured to the inside of the case; in other areas, shall be secured by adhesive to the duct or other adjacent surface and shellacked over. Instruments and equipment, whose use is self-evident, such as ordinary room thermostats, radiator valves, or similar unitary equipment valves, will not require such notations.

D. Penetrations of Ducts: All penetrations shall be properly sealed to prevent leakage around the opening; shall include a stuffing box type of closure or similar approved method.

E. Pipe Wells: Provide pipe wells for insertion of temperature sensors in water lines. Temperature sensing wells shall be of sufficient length to reach midway into pipe, with extension necks where installed or insulated piping. Wells shall be brass or stainless steel; installed in lines using tees or thread-o-lets.

F. Insertion Thermostats: Provide for all duct and water temperature sensing; capillary connected if averaging bulb type; capillary or rod and tube type for other units; nonbleed; throttling range as required for service; on water circuits, separable socket type; remote readjusting type where specified, adjustable ratio, straight line action, adjustable limit stops.

G. The freezestats used on fan shut-down control shall be wired to stop the fan in both the Auto and Hand positions of the HOA switch. Freezestats shall be overridden by the fire alarm controls.

H. Wall mounted temperature sensors shall be mounted on electrical boxes, and all wire penetrations shall be sealed to prevent thermal convection.
I. It is the responsibility of the controls vendor to ensure that all sensors are placed in the measurable flow path so as to accurately measure the sensed variable. As a minimum, water flow sensors shall be installed with a straight section of piping 10 diameters upstream and four diameters downstream.

J. Sensors installed for outside air measurement and pressurization shall be located to optimize the accuracy of the measurement. Coordinate with Mechanical Consultant.

K. Valve operators shall be installed directly above the controlled valve whenever possible (with the exception of steam control valves where actuator is rotated to about 30 degrees to avoid hot zone directly above valve) unless rotation is needed to permit maintenance access. However, in no case shall the operator be rotated to or beyond horizontal.

L. Freezestats shall be installed with capillaries supported by non-metallic standoffs. No part of the capillary shall otherwise touch the coil or frame.
   1. Provide mounting support for the capillary at least every 36 inches and at the capillary end, within 6 inches.
   2. Freezestats shall be mounted to the upstream face of the first coil that they are designed to protect, usually the cooling coil.
   3. Locate reset head on outside of plenum wall.
   4. Install such that the temperature-sensing element is sloped continuously downward from the sensing head.

M. Freezestats’ capillary length shall provide one foot of capillary for each four-square feet of coil surface (by multiple freezestat units if necessary to meet this requirement). In all cases the coil face shall be completely crossed from corner to corner, with the freezestat control head mounted at the highest capillary point to maintain calibration.

N. Dual Duct Terminal unit discharge temperature sensor shall be mounted a minimum of 36 inches downstream from the unit.

O. All devices shall be mounted within enclosures. Cable trays and external cabinet surfaces shall not be used as mounting surfaces. Proof of run for both fans and pumps shall be by current sensing devices rather than differential pressure switches.

P. All pressure indicating/measuring devices shall be installed with capped tee devices to permit attachment of test meters.

Q. Controls Mounting: Controls shall be grouped by systems, areas, or other appropriate basis concealed in locking-type wall-mounted cabinets, with proper labeling as to functions and settings marked on the front thereof, located no more than 6'-0” above the floor unless specifically approved by Owner. Control cabinets shall not be installed on ductwork or plenum walls. Mount all relays, switches, contacts, etc., in common panels. Tag each instrument by use of approved labels corresponding to symbols used on control drawings.

R. Location of Room Sensors: Where sensors are mounted at light switches, locate on centerline of the electrical outlet box, as directed. Sensors shall not be located above dimmer switches. Exact location of sensors shall be verified with final casework and furniture layouts.
S. Verify location of thermostats, CO2 sensors and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches or 60 inches above the floor. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

T. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.

U. Install automatic dampers according to Division 23, Section 233300, "Air Duct Accessories."

V. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

W. Install labels and nameplates to identify control components according to Division 23, Section 220550, "Identification for HVAC Piping and Equipment."

X. Install hydronic instrument wells, valves, and other accessories according to Division 23, 232113, Section "Hydronic Piping."

Y. Install steam and condensate instrument wells, valves, and other accessories according to Division 23, Section 232312, "Steam and Condensate Heating Piping."

Z. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

3.2 CONTROL SOFTWARE PROGRAMMING

A. Control of equipment as described in the sequence of operations and shall include:

1. Time and holiday schedules
2. Alarm limits and histories
3. Summary of data for each zone
4. Trend logs and historical data
5. All setpoints
6. Master menu
7. Dynamic color graphic Interface

B. The following Points Descriptions and Sequences of Operation shall be enhanced as necessary and included as part of the control drawings to expand and clarify information shown in the drawings.

1. Points information shall be displayed and organized by system in dynamic graphic form at the operator stations.
2. The energy reduction software and miscellaneous functions shall manage all points.
3. It shall be possible to “disconnect” any output or setpoint from the AUTOMATIC control logic and enter a MANUAL value or state from any Operator Station.
4. It shall be possible to replace any input with a MANUAL value from any Operator Station.
5. All control loop parameters for each loop shall be displayed on one display.
C. Where a point or device is indicated on a drawing, it shall be provided even if not required in a sequence of operation (sequence). Where a point or device is required for a sequence, it shall be provided even if it is not shown on a diagram or plan.

D. All setpoints indicated in the sequences are suggested initial setpoints. Actual setpoints shall be determined and programmed during system balancing and commissioning process. If actual setpoint determined during this process is substantially different from the initial suggested setpoint, request confirmation of acceptability from the A/E.

E. All setpoints and values indicated in the sequences shall be adjustable with authorized access. Owner shall determine/confirm the appropriate access level during Owner training. It shall be possible to have multiple access levels with limited range of adjustability for each level.

F. All sequences shall apply when the Operator (with proper access) allows automatic control via an Operators Station. It shall be possible to override to prevent automatic operation and take manual control of any system or equipment item. If automatic start-stop operation is not discussed in sequence for a particular device, then there shall be a manual “on-off” command feature at the Operators Station.

G. Displays: Every control device indicated on the drawings or specifications and every point required in the sequences of operation shall have information displayed at the Operators Station(s). All information displayed shall have a simple and concise description of what the information is and means. Certain display requirements are indicated in the sequences. To avoid unnecessary duplication, other more typical display requirements are not indicated in every sequence but shall be provided for every device or point as follows:

1. Every device or equipment item that has a start-stop, open-closed, on-off or similar binary output from the BAS shall have an operational status display. Display shall include multiple pieces of information, as follows:
   a. Current “on-off” command from EMCS
   b. Current “on-off” condition as sensed by proof switch (where available).
   c. Virtual “on-off” condition if a proof switch is not available, but other sensors can provide a reasonable verification of equipment operation. For example, such a reasonable verification may include using an analog pressure sensor downstream of a fan where a sensed value above a certain level could only occur if the fan was in operation.
   d. Indication as to if control is in automatic mode (controlled per sequence) or in manual mode.

2. Every device or equipment item that has a binary (open-closed contact) input to the BAS shall have an operational status display. Display shall include:


4. Every device or equipment item that has an analog control output from the BAS shall have an operational status display. Display shall include multiple pieces of information, as follows:
   b. Commanded output (percent of maximum).
   c. Display of the measured value at the controlling sensor or VFD.
d. Indication as to if control is in automatic mode (controlled per sequence) or in manual (override) mode.

5. Every device or equipment item that has an analog input to the BAS shall have an operational status display. Display shall include:
   a. Current measured condition.
   b. Whether alarm feature is active.
   c. Current setpoint for high and low alarm conditions.

6. Unless indicated otherwise in the sequences, all stated values shall be assumed to use units of measurement displayed (at operator workstations) as follows:
   a. Temperature in degree F.
   b. Humidity in relative humidity (percent).
   c. Air pressure (and differential pressure) in inches water column.
   d. Water or steam pressure (and differential pressure) in PSIG.
   e. Water flow rate in GPM.
   f. Air flow rate in CFM.
   g. Speed as percent of maximum RPM (when motor is driven at 60 hertz by VFD).

7. The following points shall be displayed using calculated values based upon commanded position unless exact values, as indicated by a feedback signal, are required by control strategy:
   a. Fan speed (per cent of full speed)
   b. Damper positions (per cent of full open)
   c. Heating and cooling valve position (per cent of full open)

H. Trend Logs: Provide trend log programming and setup for individual points as requested by the Owner up to a maximum of three percent of all inputs provided on the project.

I. Alarms: Certain special alarm requirements are indicated in the sequences. To avoid unnecessary duplication, all necessary alarm requirements are not indicated in every sequence. In addition to the listed alarms, every point shall be equipped to (potentially) have the following alarms. Each alarm shall include specific text (on screen) describing the nature of the alarm, and the source of the alarm information (such as “current sensing relay”, “differential pressure switch”, etc.) Each point shall be capable (with only programming and setup required) to alarm as follows:

1. Every device or equipment item that has a start-stop, open-closed, on-off or similar command from the BAS shall have an alarm to identify failure to operate as commanded. This alarm shall use available proof switches or other sensors that can be used as a “virtual proof”. Provide suitable delays to accommodate equipment startup times, etc.
2. Every device that has a binary (open-closed) input to the BAS that would normally be used as an alarm or service-requirement indicator (such as a differential pressure switch at a filter) shall provide suitable alarm annunciation.
3. Every device or equipment item that has an analog control output from the BAS shall have an alarm to identify failure of system to maintain setpoint at the controlling sensor. Provide suitable delays to accommodate equipment startup times, etc. Establish
reasonable high and low condition alarm trigger points to accommodate normal and reasonable variations in system output.

4. Every VFD shall have an alarm contact monitored by the EMCS to acknowledge any faults. It shall also have an additional alarm contact monitored by the BAS to acknowledge if it is in the bypass mode.

J. Alarm Programming: Provide alarm programming and setup for all alarms specifically indicated in the sequences of operation, and at additional points as requested by the Owner up to a maximum of 20% of all inputs provided on the project. Assign operator high and low alarm limits according to design data or as Owner requests. It is assumed that Owner will want alarms to be set up for all filter switches and at all inputs indicated, but not addressed in the sequences.

K. Additional Control Requirements: Auxiliary Air Conditioning Units: Provide all control work required for all auxiliary air conditioning units. Include field wiring for any remote devices provided with each unit. Systems shall be controlled per manufacturer's recommendations and as follows: Provide DDC temperature sensor except where sensors are furnished with equipment.

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All electrical control wiring and terminations for the control system shall be provided by the controls subcontractor,

B. Install raceways, boxes, and cabinets according to Division 26, Section 260533, "Raceway and Boxes for Electrical Systems."

C. Install building wire and cable according to Division 26, Section 260519, "Low-Voltage Electrical Power Conductors and Cables."

D. Install signal and communication cable according to Division 27, Section 271500, "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 WORK BY OTHERS

A. The mechanical subcontractor shall install all wells, pressure tappings for flow sensors, etc., and shall set all control valves in place under the manufacturer's supervision. Pressure taps shall include service valves and calibration taps.

B. The sheet metal subcontractor shall approve or correct the submitted schedule of required control damper quantities and sizes before dampers are ordered from the factory. Sheet metal Contractor shall receive dampers at the job site, set dampers in place under the manufacturer's supervision and provide an access door for each damper. Dampers shall be mounted square within the duct without twisting or distortion to insure proper damper operation. The damper shaft shall be extended at a location that provides space for the actuator.

C. Patching and painting required for the control system installation will be accomplished by the General Contractor.

D. All line voltage wiring required for control panels, alternators, motor starters are to be furnished and installed by the electrical subcontractor.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Pressure test control air piping at 30 psig or 1.5 times the operating pressure for 24 hours, with maximum 5-psig loss.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
7. Test each system for compliance with sequence of operation.
8. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:
   a. Verify that DDC controller power supply is from emergency power supply, if applicable.
   b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
   c. Verify that spare I/O capacity has been provided.
   d. Verify that DDC controllers are protected from power supply surges.

   D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6 ADJUSTING

A. Calibrating and Adjusting:
   1. Calibrate instruments.
   2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
   3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
   4. Control System Inputs and Outputs:
      a. Check analog inputs at 0, 50, and 100 percent of span.
      b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
      c. Check digital inputs using jumper wire.
      d. Check digital outputs using ohmmeter to test for contact making or breaking.
      e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

   5. Flow:
      a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
      b. Manually operate flow switches to verify that they make or break contact.

   6. Pressure:
a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:
   a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
   b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.7 DEMONSTRATION AND ACCEPTANCE.

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01, Section 017900, "Demonstration and Training."

B. The building controls system subcontractor shall submit a proposed Acceptance Test Agreement for testing the system's functionality and the accuracy of all sensors and actuators.

C. The system installation shall be complete in all respects and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Engineer requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within 30 calendar days of the request. When the system has been deemed satisfactory in whole or in part by the Owner's representative, the system will be accepted for beneficial use which will start the warranty period for the commissioned portion.

3.8 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.
C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230900
SECTION 232300 – REFRIGERANT PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Sections 230500 and are directly related to work included in this section. Other sections are indirectly related and shall be reviewed.

1.2 WORK INCLUDED

A. Work under this section shall include furnishing all labor, materials, tools, and equipment necessary for the complete installation of the field refrigerant piping as shown in the project drawings.

B. Products installed but not furnished under this Section include pre-charged tubing, refrigerant specialties, and refrigerant accessories furnished as an integral part of or separately with packaged air conditioning, cooler, and freezer equipment.

PART 2 – PRODUCTS

1.3 PIPING AND FITTINGS

A. Refrigerant Piping: Copper refrigerant tube, ASTM B280, cleaned, dehydrated and sealed, marked ACR on hard temper straight lengths. Coils shall be tagged ASTM B280 by the manufacturer. Use type K copper where required by governing code. R410a piping shall be UL rated to minimum 700psi working pressure.

   1. Acceptable manufacturers:

      a. Mueller Industries
      b. Cerro Flow Products, Inc.
      c. CMC Howell Metal

B. Water and Drain Piping: Copper water tube, ASTM B88, Type L, or refrigerant tube ASTM B280.

C. Fittings, Valves and Accessories:


      a. Solder, refrigerant tubing: Cadmium free, AWS A5.8, 45 percent silver brazing alloy, Class BAg-5.
b. Solder, water and drain: 95-5 tin-antimony, ASTM B32 (95TA).
c. Fittings for R-410a shall be UL rated to minimum 700psig working pressure.
d. Acceptable manufacturers:
   1) Mueller Industries
   2) NDL Industries


3. Refrigeration Valves:
   a. Low pressure R410A valves to be rated to a minimum 300psig working pressure and high pressure R410a valves to be rated to a minimum 700psig working pressure.
   b. Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, backseating, full port construction, rupture proof encapsulated stem.
   c. Pressure Relief Valves: Forged brass with nonferrous, corrosion resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ANSI/ASHRAE Standard 15.
   d. Solenoid Valves: Comply with ANSI/ARI 760 and UL 429; listed and labeled by a NRTL. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice shall be stainless steel construction. Seat shall be Polytetrafluoroethylene. Two-position, direct acting or pilot-operated, moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location. Provide normally open or closed holding coil as required.
   e. Thermostatic Expansion Valves: Brass body with stainless-steel or non-corrosive non-ferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Adjustable superheat. Solder-end connections. Minimum 450psig working pressure for non-R-407a applications. Testing and rating in accordance with ANSI/ASHRAE Standard 17. Comply with ARI 750.
   a. Check Valves: Brass or bronze alloy with globe pattern. Piston shall have removable polytetrafluoroethylene seat. Bonnet shall be bolted ductile iron, forged brass, or cast bronze; or brass hex plug. Minimum 500psig working pressure for non-R-407a applications. Closing spring shall be stainless steel. Swing or lift type operation maximum operating 0.50psi pressure, and with solder-end connections. Direction of flow shall be legibly and permanently indicated on the valve body.
   b. Strainers: Designed to permit removing screen without removing strainer from piping system and provided with screens 80 to 100 mesh in liquid lines up to 1-1/8 inch, 60 mesh in liquid lines over 1-1/8 inch, and 40 mesh in suction lines. Provide strainers in liquid line serving each thermostatic expansion valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.

4. Refrigerant Moisture/Liquid Indicators: Double-ported type having replaceable, clear, fused, sight glass sealed into forged bronze body with indicating element protected by filter screen. Provide screwed brass seal caps. Indicator to be color coded to show moisture in ppm, Minimum moisture indicator sensitivity shall indicate moisture above 60 ppm. Minimum 500psig working pressure for non-R-410a applications.
5. Refrigerant Filter-Dryers: UL listed, angle or in-line type, as shown on drawings. Conform to ANSI/ASHRAE Standard 63, ARI 730. Heavy gage steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size and desiccant media to be recommended by manufacturer for service and capacity of system. Connection not less than the line size in which installed NPS 1/4 access port connections at entering and leaving sides for pressure differential measurement. Heat-pump applications shall be reverse flow. Minimum 500psig working pressure for non-R-410a and 800psig for R-410a applications. 10 micron filter media with pleated with integral end rings and stainless-steel support. Maximum operating pressure loss shall be 2psig. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.

6. Flexible Metal Hose: Seamless bronze corrugated hose, covered with bronze wire braid, with standard copper tube ends. Provide in suction and discharge piping of each compressor.

7. Water Piping Valves and Accessories: Refer to specification Section 15180, Heating Piping.

8. Steel construction: equipped with tappings for liquid inlet and outlet valves, pressure relief valve and liquid level indicator.

1.4 PRESSURE-TEMPERATURE GAGES

A. Fed. Spec. GG, Type III (freon), 2-1/2 inch minimum diameter, bottom connection, one percent accuracy, graduated in gauge psig and corresponding refrigerant temperature, with pressure snubber. Stainless steel case, stainless steel movement, temperature suitable for refrigerant. Manufacturer: Duro Instrument Corporation, or approved Marsh, Winters, Crosby or Moeller.

B. Provide board-mounted gages of the following ranges for each compressor. Provide gauge shut-off valve.

   1. Typical refrigerant
      a. Suction: 30 inches Hg vacuum to gauge 250-psig.
      b. Discharge: 0 to 500-psig.

   2. R-410a
      a. Suction: 30 inches Hg vacuum to gauge 400-psig.
      b. Discharge: 0 to 800-psig.

1.5 PIPE SUPPORTS

A. Refer to specification Section 230500.

1.6 REFRIGERANTS AND OIL

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

   1. Atofina Chemicals, Inc.
2. Chemours.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. Provide oil type and quantity as per refrigeration system OEM installation manual.

C. Refrigerant in accordance with ANSI/ASHRAE Standard 34.

1.7 PIPE INSULATION FOR DX HVAC SYSTEMS

A. General

1. All refrigerant copper lines shall be free of extraneous chemicals such as corrosive
   cleaners or building materials dust prior to the installation of the insulation.
2. Refrigerant pipe shall be sealed while slipping on insulation to prevent foreign matter
   from entering tube.
3. Insulation shall be slid onto pipe, longitudinal slitting of the insulation is not allowed
   except on mitered sections. Insulation shall be pushed on pipe, not pulled.
4. Insulation shall be mitered, pre-adhered and longitudinally slit to fit over all P-traps, tees
   and elbows or bends over 90°.
5. All butt joints and mitered seams shall be adhered with full coverage of adhesive on both
   surfaces. Insulation shall not be stretched while adhering.
6. At the beginning and ends of piping runs, the insulation shall be adhered directly to the
   copper pipe using a 2-inch strip of adhesive. Insulation should not be adhered to the pipe
   at the extreme low points in any piping run.
7. Saddles or piping shields shall be installed under all insulated lines at clamps, clevis
   hangers, or locations where insulation may be compressed. Wood dowels or blocks, of a
   thickness equal to the insulation, shall be inserted and completely sealed into the
   insulation if the excessive compression of the insulation remains at the saddle locations.
8. Hangers clamped directly over the pipe shall be insulated over the hanger, insulation
   shall be fully adhered to the hanger. In addition, hangers with double rods shall be
   insulated between the rods. All seams of the insulation shall be sealed with adhesive.
9. All flexible elastomeric insulation exposed to sunlight or installed outdoors shall be
   protected with 2 coats of an approved UV-resistant finish after the adhesive is dry.

B. Flexible Elastomeric Closed-Cell Pipe Insulation: ASTM C534, flexible, molded or sheet.
   Materials shall have a minimum thermal conductivity of 0.27 Btu-in. per sq.ft. per °F per hour
   at a mean temperature of 75°F when tested in accordance with ASTM C177 or ASTM C518,
   latest revisions. Maximum service temperature, 180 °F. Materials shall have a flame spread
   rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with
   ASTM E84, latest revision. Materials shall have a minimum water vapor transmission of 0.08
   per-inches when tested in accordance with ASTM E96, Procedure A, latest revision. Provide
   waterproof vapor retarder adhesive. Insulation exposed to outdoors shall be provided with UV
   protection.

1. Manufacturer: Armacell "AP Armaflex" with Armacell No. 520 joint adhesive or
   Aeroflex "Aerocel" with Aeroseal joint adhesive.

C. Glue: A contact adhesive specifically formulated for bonding insulation materials which
   ensures a moisture resistant permanent bond between applied materials. Must form a non-
flammable material when dried and is approved for use with insulation materials to be installed:

1. Acceptable Manufacturers and products:
   
a. Armaflex® 520 Adhesive
b. K-Flex® 620 Contact Adhesive-Black
c. K-Flex 320 Contact Adhesive-Amber

D. Sealant: Comply with USGBC LEED requirements.
   
1. Acceptable manufacturer and product: Sealant (SLNT-4) - Sanitary silicone rubber sealant conforming to ASTM C 920, Type S, Grade NS, Class 25 Dow Corning® 786 Mildew Resistant Silicone Sealant or equal. VOC – 33 g/L.

E. Insulated pipe support systems shall be by one of the following:
   
1. Insulation couplings as manufactured by Klo-Shure®.
2. Armafix™ insulated inserts as manufactured by Cooper B-Line® Inc or ZSI Inc.
3. Aerofix™ insulated inserts as manufactured by Aeroflex USA, Inc.
4. K-Flex 360 Insulated Pipe Supports as manufactured by K-Flex USA.

F. Protective coatings:
   
1. Acceptable Manufacturers
   
   b. K-FLEX WT Clad N/S (non-split) tube insulation with fully adhered PVC jacket and K-Flex pre-formed fittings.
   c. Aeroflex USA, Inc., SaniGuard™ 30 mil PVC jacket and pre-formed fitting covers.

G. Install the following minimum insulation thicknesses. Enlarge as code requires:

<table>
<thead>
<tr>
<th>Piping and Refrigerating Specialties Temperature (deg F)</th>
<th>Piping Up to 2” dia.</th>
<th>Piping 2” to 4” dia.</th>
<th>Piping 4” to 6” dia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-cooled Low Temp. Liquid Lines</td>
<td>1/2”</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Suction above plus 25 deg F</td>
<td>3/4”</td>
<td>3/4”</td>
<td>3/4”</td>
</tr>
<tr>
<td>Suction plus 10 deg F to plus 25 deg F</td>
<td>3/4”</td>
<td>1”</td>
<td>1”</td>
</tr>
<tr>
<td>Suction minus 10 deg F to plus 10 deg F</td>
<td>1”</td>
<td>1”</td>
<td>1-1/4”</td>
</tr>
<tr>
<td>Suction minus 30 deg F to minus 10 deg F</td>
<td>1-1/4” (1” in areas below ceiling and in false columns)</td>
<td>1-1/4” (1” in areas below ceiling and in false columns)</td>
<td>1-3/8” (1” in areas below ceiling and in false columns)</td>
</tr>
</tbody>
</table>
PART 3 – EXECUTION

1.8 INSTALLATION

A. Install refrigerant piping and refrigerant containing parts in accordance with ANSI/ASHRAE Standard 15 and ANSI/ASME B31.5. Refrigerant piping shall be brazed with 15 percent silver solder in accordance with ANSI/AWS A5.8.

1. The equipment manufacturer establishes maximum piping length between components of the cooling/heating system. It is the contractor responsibility to verify that these piping lengths are not exceeded during installation.

2. Install piping as short as possible, with a minimum number of joints, elbow and fittings.

3. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide one-inch minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation. Seal all pipe sleeve openings.

4. Accurately measure, and cut refrigeration piping to length with a tubing cutter. Do not use a hacksaw or abrasive type cutter on refrigeration piping.

5. Ream cut ends to full diameter, and remove burrs created during cutting process.

6. Carefully assemble all joints prior to brazing, inserting tube all way into the fitting cup, firmly against stop.

7. Install piping with sufficient flexibility to allow for expansion and contraction due to temperature fluctuations inherent in operation of these types of refrigeration systems.

8. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.

9. Use copper tubing in protective conduit when installed below ground. Seal ends of all underground conduit.

10. Use copper fittings to make changes in direction. For piping 5/8” OD or less, changes in direction can be made using tubing bender on hard copper piping. No soft copper allowed for piping or changes in direction with the exception of case liquid line expansion loops.

11. Use factory-fabricated fittings for piping transitions. No crimping, swaging, or stab-in connections allowed.

12. Install piping to prevent vibration and undue strain on pipe and fittings.

13. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.

14. Install hangers and supports per ANSI/ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators
and other equipment tightly capped until assembly. **Do not leave open refrigerant piping ends unattended during installation process!** Visibly inspect pipe and fittings prior to assembly. Swab as necessary with alcohol-soaked cloth to remove dirt, filings, or visible moisture.

C. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

D. Protect affected valves and control devices during brazing process by disassembling and removing heat sensitive parts or use of heat shields or wet towel wraps.

E. The Owner may, at their discretion require refrigeration contractor or equipment manufacturer to remove up to 5 joints from their refrigeration system or equipment to inspect for oxidation. If 1 joint is found to have signs of scaling, additional joints shall be removed. If 4 joints are found to be oxidized, responsible entity shall re-work all joints at their expense.

F. **Joints**

1. Soldered joints per ASTM B828 or CDA's "Copper Tube Handbook."
   a. Use Type BeuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
   c. Braze in refrigerant piping with suitable high temperature silver solder alloy containing not less than 15 percent silver for copper to copper connections and 45 percent silver for connection of copper to copper-to-steel, brass-to-steel, or steel-to-steel joints.
   d. Continuously flush piping during brazing process with dry nitrogen to prevent excess oxidation and scaling.
   e. The Owner reserves the right to inspect refrigeration system for oxidation.

3. Use only long-radius fittings. Short radius and 45º fittings are not allowed.

G. Invert: Install piping in a neat and workmanlike manner with horizontal runs sloped continuously downward toward compressor rack at a rate of 1-inch per 20 feet. Headers: Suction headers to have individual circuits entering top of header. Liquid headers to have individual circuits exiting side or bottom.

H. **Oil Traps:**

1. Required at base and inverted trap at top of suction risers exceeding 6 feet in length.
2. Intermediate traps required every 15 feet for vertical suction riser.

I. Pipe relief valve discharge to outdoors for systems containing more than 100 pounds of refrigerant.

J. **Firestopping:** Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 230500, Basic Materials and Methods.
K. Seismic Bracing: Refer to specification Section 230548, BASIC Materials and Methods, for bracing of piping in seismic areas.

L. Owner's representative shall visually inspect refrigerant piping and insulation prior to being covered.

1.9 PIPE AND TUBING INSULATION

A. Apply flexible cellular insulation and fabricate fittings in accordance with the manufacturer's written instructions.

B. Use proper size material. Do not stretch or strain insulation.

C. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under specification Section 230500, Basic Materials and Methods.

D. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed.

E. Apply weather-resistant finish as recommended by the manufacturer to insulation exposed to outdoor weather.

1.10 SIGNS AND IDENTIFICATION

A. Each refrigerating system erected on the premises shall be provided with an easily legible permanent sign securely attached and easily accessible, indicating thereon the name and address of the installer, the kind and total number of pounds of refrigerant required in the system for normal operations, and the field test pressure applied.

B. Systems containing more than 110 lb of refrigerant shall be provided with durable signs, in accordance with ANSI A13.1 and ANSI Z53.1, having letters not less than 0.5 inch in height designating:

1. Valves and switches for controlling refrigerant flow, the ventilation and the refrigerant compressor(s).
2. Signs on all exposed high pressure and low-pressure piping installed outside the machinery room, with name of the refrigerant and the letters "HP" or "LP."

1.11 FIELD QUALITY CONTROL

A. Prior to concealing joints with insulation or piping in walls, floors, or ceilings clean and test in accord with ANSI/ASME B 31.5, “Refrigerant Piping”. These sections of piping must be installed entirely leak-free and remain pressurized until their final connection is made. Equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and the Contractor shall correct ANSI codes for pressure piping.
1.12 FIELD TESTS

A. After completion of piping installation and prior to initial operation, conduct test on piping system according to ANSI/ASME B31.5, Chapter VI. Furnish materials and equipment required for tests. Perform tests in the presence of A/E. If the test fails, correct defects and perform the test again until it is satisfactory and all joints are proved tight.

1. Every refrigerant-containing part of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms and systems that are factory tested, shall be tested and proved tight after complete installation, and before operation.

2. The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively, except systems erected on the premises using non-toxic and non-flammable Group A1 refrigerants with copper tubing not exceeding 0.62 in O.D. This may be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 68 degrees F minimum.

B. Test Medium: A suitable dry gas such as nitrogen or shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a gage on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

1.13 SYSTEM TEST AND CHARGING

A. System Test and Charging: As recommended by the equipment manufacturer or as follows:

1. Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 10-psi gage. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.

2. Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side. Refer to Part 1, Quality Assurance. Test entire system again for leaks.

3. Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gage reading in microns. Pull the system down to 500 microns and hold for four hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with the refrigeration to be charged and charge with the proper volume of refrigerant.

1.14 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.

1.15 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start-up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

D. System commissioning procedures and deliverables to be in accordance with local code.

1.16 OWNER TRAINING

A. Train Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.

B. Review data in Operating and Maintenance Manuals. Refer to Section 230500, "Mechanical Work—General".

C. Owner training and deliverables to be in accordance with local code

END OF SECTION 230184
SECTION 233100 - METAL DUCTS AND CASINGS

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 metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg and metal casings. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round, and flat-oval spiral-seam ducts and formed fittings.
3. Double-wall, round, and flat-oval spiral-seam ducts and formed fittings.
4. Duct liner.
5. Turning vanes.

B. Related Sections include the following:

1. Division 23 Section "Nonmetal Ducts" for fibrous-glass ducts, thermoset FRP ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, and flexible ducts.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.


1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.
1.5 SUBMITTALS

A. Submit shop standard for ductwork construction utilized on this project. Include proposed duct gage, reinforcement interval, seam and joint construction for all sizes and pressure classes of rectangular, round, and oval ductwork. Submit construction standard for all plenums and fittings.

B. Detailed Shop Drawings are a cost factor for Contractor and require considerable time for review. Require them only if Drawings do not show enough detail, or for complex areas, and only if you intend to review them. List those areas where shop drawings are required, such as for Canopy Hoods.

C. Shop Drawings: CAD-generated and drawn to scale. Show fabrication and installation details for metal ducts.

1. Required in the following areas: <fill in areas>
2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
3. Duct layout indicating sizes and pressure classes.
4. Elevations of top and bottom 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. Duct accessories, including access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.

D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.
3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

E. Submit Welding Procedure Specification, Procedure Qualification Test Record, and Welder and Welding Operator Qualification Test Record.

F. Field quality-control test reports.

G. LEED Submittals:

1. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."

3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1-2004, Section 6.4.4.2.2 - "Duct Leakage Tests."

4. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1-2004, Section 7.2.4 - "Ventilation System Start-Up."

5. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.

1.6 QUALITY ASSURANCE


B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Duct Protection, Cleaning, and Cleanliness Testing: Comply with requirements in Part 3 of this specification for protection, cleaning, and cleanliness testing of ductwork.


PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 General requirements –ductwork and Plenums

A. Construction: Primary air duct construction, fittings, reinforcements, pressure and seal classifications and metal gauges shall conform to SMACNA HVAC/DCS, 2005 Edition including Addendum No. 1, 2005 SMACNA Duct Construction Standards and NFPA90A unless noted otherwise.
B. Ducts and accessories shall not pulsate or vibrate when in operation.

C. Test Ports: Provide instrument test holes with screw cap and gasket. Instrument test holes shall be attached to ducts and plenums with bolts. Seal around bolt head with duct sealant. Provide gasket to fit duct shape (rectangular or round) as needed. Provide all such test holes in ducts with instrument adapter as required for static pressure readings; exact location to be coordinated with air balancing contractor.

1. Available Manufacturer: Ventfabrics No. 699

D. Stuffing Boxes: Provide airtight stuffing boxes at all penetrations for instrumentation, such as sensors, thermostats, thermometers, pipes, etc.; use rubber grommets or U-channel rubber extrusions to create airtight seal.

1. Available Manufacturer: “Rubbercraft”.

E. At connections to building construction, use steel angles fastened to the sheet metal by sheet metal screws, attached using anchor bolts embedded in the wall or slab, with sealant under the angle, angles 2”x2”x3/16” minimum.

2.3 SHEETMETAL DUCTWORK

A. General: All ductwork shall be of sheet metal construction.

B. Pressure and Seal Classification: Unless otherwise indicated, construct ducts according to the following:

1. Supply ducts from outlet of air handlers and fans to terminal units: +4-in wg OR +6-in wg. Seal Class A.
2. Supply ducts downstream of terminal units: +1/2-in wg OR +1-in wg OR +2-in wg Seal Class A.
3. Return ducts: Negative 2-in wg, except ductwork from last volume damper to grille may be negative 1-in wg. Seal class A.
4. Exhaust ducts: Negative 1-in wg. Seal Class A.
5. Exhaust ducts serving isolation rooms: Negative 2-in wg. Seal Class A.
6. Any ductwork upstream of any fire, smoke or combination fire/smoke damper conveying more than half of the total terminal airflow: +4-in wg. Seal Class A.
7. Note that you may want to specify G-90 for ducts with lots of moisture.

C. Material schedule:

1. All ducts shall be galvanized steel unless otherwise specified.
2. Shower exhaust duct shall be made of aluminum to the first main connection.

D. Galvanized Steel: Steel sheets, G-60 zinc-coated (galvanized) or zinc-iron alloy coated (galvannealed) by the hot dip process, conforming ASTM A653 unless noted otherwise.

1. Rectangular Ductwork: Aluminum ductwork shall comply with the requirements of low pressure galvanized steel ductwork. Thickness adjustments of aluminum, including dimension adjustments and reinforcements needed to meet the construction requirement thickness of steel ducts, shall comply with SMACNA 2005 HVAC/DCS, Article 1.12.1, "Conversion of Steel Tables to Aluminum."

2. Round Ductwork: Construction of aluminum duct and fittings shall otherwise correspond in the same relationship as for steel duct. Conform to SMACNA 2005 HVAC/DCS, Table 3-3, "Aluminum Round Duct Gage Schedule." Aluminum fasteners shall be used. Structural members shall be alloy 6061-T6 or galvanized steel as related in SMACNA Table 1-16 for rectangular duct. Hangers in contact with the duct shall be galvanized steel or aluminum.

F. Stainless Steel: Comply with ASTM A 480/A 480M, Type 304 OR 316L, cold rolled, annealed, sheet.

G. Flat oval ductwork is not permitted on exhaust or return systems.

H. Pressure classes refer to both positive and negative ducts in absolute numbers unless noted otherwise.

I. Round or Oval Elbow Construction: Round or oval segmented or mitered elbows shall be minimum 3-gore for 45°, 4-gore for 60°, and 5-gore for 90°. Adjustable round elbows are not permitted.

J. Bellmouth transitions shall be used on connections to air handling units and plenums.

K. Rectangular Elbows shall be radius or short radius with vanes, type RE 1 and RE 3 in the SMACNA manual. Mitered elbows with turning vanes and other types shall not be used, use short radius elbows with vanes where space is limited. Construct vanes per pages 4.5 and 4.6 (Figures 4-3 and 4-4) of the SMACNA manual.

L. Turning vanes for rectangular elbows:

1. Turning vanes shall be welded to runners at velocities exceeding 2,500 fpm.

2. All sheet metal duct pressure classes and velocities: Airfoil Turning Vane is acceptable. Non-adjustable, double wall 26-gauge hot dipped galvanized steel, true airfoil type air turning vanes at square duct elbows. Factory runner, 24-gauge, with vanes 2.4” o.c. Available Manufacturer: “Aero Dyne Company”, Model HEP.

3. 2” wg. Pressure Class ducts or lower with velocities at or below 1500 fpm: 2” single width vanes, spaced 1.5” o.c. may be used when spanned lengths are 36” or less. Non-adjustable, single wall 24-gauge vane per SMACNA Fig. 4-3 & 4-4. Rail shall be 24-gauge. Available Manufacturer: “Duro Dyne”, “Ductmate” Monorail.

4. 3” wg. Pressure Class or higher ducts at any velocity and where duct velocities in any pressure class exceed 1500 fpm: 2” double width vanes, spaced 2.125” o.c. shall be used when spanned lengths are 48” or less. This vane is acceptable at lower pressure classes and velocities. Non-adjustable, double wall 26-gauge vane per SMACNA Fig. 4-3 & 4-4. The 22-gauge vane runner shall be of the tabbed style and shall have bent, or winged tabs. Straight tabs are not permitted. Available Manufacturer: “C.L. Ward & Family Inc.” Turning Vane and Speedy Rail, “Ductmate” Turning Vane and PROrail.

5. 3” wg. Pressure Class or higher ducts at any velocity and where duct velocities in any pressure class exceed 1500 fpm: 4.5” double width vanes, spaced 3.25” o.c. may be used
when spanned lengths are 72” or less. Provide tie-rods for spans in excess of 72”. This vane is acceptable at lower pressure classes and velocities. Non-adjustable, double wall 24-gauge vane per SMACNA Fig. Fig. 4-3 & 4-4. Vane runner shall be of the tabbed style and shall have bent, or winged tabs. Straight tabs are not permitted. Available Manufacturer: “C.L. Ward & Family Inc.” Turning Vane and Speedy Rail, “Ductmate” PROrail.

M. Seams: All seams shall conform to SMACNA standards for the corresponding pressure and seal class and to the requirements in this specification.

1. Round and oval duct seams shall be spiral seam or continuous butt weld construction only.
2. Rectangular seams for 3-in wg pressure class or higher shall be SMACNA L-1 Pittsburgh Lock or continuous butt weld only.
3. Rectangular seams for 2-in wg pressure class or lower shall be continuous butt weld, SMACNA L-1 Pittsburgh Lock, or SMACNA L-2 Button Punch Snap Lock.
4. Do not use standing seams for ducts other than plenums

N. Joints: All joints shall conform to SMACNA standards for the corresponding pressure and seal class and to the requirements in this specification.

O. Rectangular Joints: Provide prefabricated slide-on transverse duct connectors and components. Install per manufacturer guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcement(s). Formed-on SMACNA flanges T-25a (T.D.C.) or T-25b (T.D.F.) will not be accepted.

1. Acceptable Manufacturers:
   a. “Ductmate Industries” 25, 35, and 45
   b. “Nexus” G and J
   c. “W.D.C.I.” J and H

2. Rectangular joints for 2-in wg pressure class or lower may also be SMACNA
   a. T-24 flanged with gasket
   b. T-1 Drive Slip with T-5, T-6, T-10, T-11, or T-12 S Slip

P. Round Joints: Factory fabricated transverse spiral and round duct joints conforming to SMACNA standards RT-1 through RT-6 are acceptable for ducts 20” in diameter and under. Prefabricated connectors for duct joints are permitted as noted below. Install per manufacturer guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcement(s).

1. 3”-14” Diameter: Install duct with a one piece round duct connector that includes a polyethylene gasket liner and single bolt closure. “Ductmate Industries” Quick-Sleeve Round Duct Connector, “Ward Industries” Quick Connect Model QCC (up to 12” only) or approved equal.
2. 14”-72” Diameter: Install duct using a three-piece, gasket flanged joint consisting of two internal flanges, with integral mastic sealant and one external closure band, which compresses the gasket between the internal flanges. “Ductmate Industries” Spiralmate or approved equal.
Q. Flat Oval Joints: Factory fabricated transverse flat oval duct joints conforming to SMACNA standards are acceptable for ducts with a major axis of 20” or under. Prefabricated connectors for duct joints are permitted as noted below. Install per manufacturer guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcement(s).

1. Roll formed minor axis (semicircular) flanges with integral sealant. Straight roll-formed flange with integral sealant cut to length for major axis sizes. Precision stamped connector pieces. Extruded Butyl or Neoprene gasket applied to the face of the mating flanges and screw-type cleats at manufacturer-specified intervals around perimeter of the connection. Approved manufacturers: “Ductmate Industries” Econoflange Oval Duct Connection System.

R. Note: Edit the Duct Fitting Requirements detail as needed. This typically goes on sheet M0.1. Ask Owner if they want access panels at return and exhaust turning vanes for cleaning and inspection. This adds cost and is a potential leak site.

S. See Duct Fitting Requirements detail on drawings for acceptable configurations for offsets, transitions, and take-offs.

T. Diagonal Creasing for ducts 3-in wg or lower: Provide on all panels wider than 18”. At Contractor's option, in place of diagonal creasing required for panels wider than 18”, all such panels may have machine-formed transverse ribbed stiffening on 12” centers, provided such stiffening accomplishes stiffness and freedom from buckling or breathing, and does not lessen airtightness at seams and joints.

U. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

V. Flanged Joint Sealant: Comply with ASTM C 920.

2. Characteristics: Type S, Grade NS, Class 25, Use O.
3. If low-emitting materials are required for LEED-NC Credit EQ 4.1: use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

W. Gaskets in Flanged Ducts: Use soft neoprene or extruded butyl.

X. Specify safety relief access doors as needed and show locations and pressure settings on the drawings. Fan systems will fire dampers are particularly susceptible to duct blowout or collapse, even with a high static cutout switch on the fan.
Y. Safety Relief Access Doors: Provide positive and/or negative pressure safety relief access doors in ducts to prevent blowout or duct collapse. Provide at locations indicated on the drawings.

1. Acceptable Manufacturer: United McGill Airflow Corporation ARR or ASR or approved SMACNA design.

2.4 DOUBLE-WALL DUCT AND FITTING FABRICATION

A. Manufacturers:

1. Lindab Inc.
3. Or equal.

B. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.

1. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner duct and insulation and in metal thickness specified for single-wall duct.
2. Insulation: 2-inch thick fibrous glass. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components and reduce outer shell diameter to inner duct diameter.
   a. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
3. Solid Inner Ducts: Use the following sheet metal thicknesses and seam construction:
   a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral-seam construction.
   b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral-seam construction.
   c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral-seam construction.
   d. Ducts 62 to 88 Inches in Diameter: 0.034 inch with standard spiral-seam construction.

4. Perforated Inner Ducts: Fabricate with 0.028-inch thick sheet metal having 3/32-inch diameter perforations, with overall open area of 23 percent. Provide Mylar or Tedlar layer to separate insulation from air stream.

5. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.

C. Fittings (from minus 2- to plus 10-inch wg): Fabricate double-wall (insulated) fittings with an outer shell and an inner duct.

1. Solid Inner Ducts: Use the following sheet metal thicknesses:
   a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
2. Perforated Inner Ducts: Fabricate with 0.028-inch-thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent. Provide Mylar or Tedlar layer to separate insulation from air stream.

2.5 SHEETMETAL MATERIALS

A. Galvanized Steel: Steel sheets, G-60 zinc-coated (galvanized) or zinc-iron alloy coated (galvannealed) by the hot dip process, conforming ASTM A653 unless noted otherwise.


1. Rectangular Ductwork: Aluminum ductwork shall comply with the requirements of low pressure galvanized steel ductwork. Thickness adjustments of aluminum, including dimension adjustments and reinforcements needed to meet the construction requirement thickness of steel ducts, shall comply with SMACNA 1995 HVAC/DCS, Article 1.12.1, "Conversion of Steel Tables to Aluminum".

2. Round Ductwork: Construction of aluminum duct and fittings shall otherwise correspond in the same relationship as for steel duct. Conform to SMACNA 1995 HVAC/DCS, Table 3-3, "Aluminum Round Duct Gage Schedule". Aluminum fasteners shall be used. Structural members shall be alloy 6061-T6 or galvanized steel as related in SMACNA Table 1-16 for rectangular duct. Hangers in contact with the duct shall be galvanized steel or aluminum.

C. Stainless Steel: Unless indicated otherwise, Type 316L stainless steel, not to exceed 0.03% carbon, conforming to ASTM A240/A240M.

2.6 CANOPY HOODS

A. General: Provide the canopy hoods where indicated on the drawings.

B. Construction: All exposed portions of hood shall be 18-gauge, Type-304 stainless steel with all joints welded, ground and polished No. 4 finish.

C. Joints and Seams: GTAW, butt-welded same as fume exhaust ductwork to ensure a true level surface. All exposed welds shall be ground and polished to produce a uniform finish over the entire surface.

D. There shall be no evidence of weld pits or holes in the finished surface.

2.7 CASINGS AND PLENUMS

A. Sheet metal for casings and plenums less than 10 feet height or width shall be 18-gauge galvanized steel. Casings and plenums 10 feet or greater width or height shall be 16-gauge. Provide continuous 2"x2"x3/16" steel angle framing on 18" centers to support the sheet metal work. Fasten lapped type seams to framing on 4" centers or standing type seams to framing on 12" centers. Provide supplementary continuous 2"x2"x3/16" steel angle bracing on horizontal
surfaces to prevent deformation under system operating and "upset" pressures. Fasten sheet metal to backup angle framing and bracing with No. 8 minimum size hardened steel sheet metal screws.

B. In coil sections, humidifier sections, and outdoor intake plenums or ducts, sheet metal shall be G90 coated galvanized steel unless indicated otherwise on the drawings.

C. Where system pressures may exceed the capabilities of the construction noted above, notify the A/E prior to fabrication. Casings and plenums shall be constructed to withstand not less than 133% of the rated pressure without structural failure. Wall and roof deflections at the rated pressure shall not exceed 1/8" per foot of width.

D. Pipe penetrations of casings and plenums shall be sealed to prevent air leakage and condensation movement through the seal.

E. Joint Sealant: Fire retardant, high bonding type sealer, UL723/E84, Class I flame spread rating. Adhesive-backed cloth or metallic furnace tape will not be acceptable.

2.8 RECTANGULAR DUCT LINER

A. Provide at locations shown on drawings.

B. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.

1. Available Manufacturers:
   a. CertainTeed Corp.; Insulation Group “Ultra-Lite”
   d. Pittsburg Plate Glass ”Textrafine”
   e. Owens Corning “Aeroflex”

2. Acoustical Properties: The material shall be tested by an independent testing laboratory to determine the sound absorption coefficient in accordance with ASTM C423 using Type A mounting. The sound absorption coefficients shall meet or exceed the following values:

<table>
<thead>
<tr>
<th>Octave Band Center Frequency Hz</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness 1&quot;</td>
<td>0.13</td>
<td>0.45</td>
<td>0.45</td>
<td>0.65</td>
<td>0.74</td>
<td>0.90</td>
</tr>
<tr>
<td>Thickness 2&quot;</td>
<td>0.25</td>
<td>0.73</td>
<td>0.94</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
</tbody>
</table>

3. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
   a. Thickness: 1 inch
   b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
d. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
e. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.

1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
3) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

C. Flexible Elastomeric Duct Liner: Comply with NFPA 90A or NFPA 90B.

1. Available Manufacturers:
   a. Aeroflex USA Inc.; Aerocell EDPM
   b. Armacell; AP/Armaflex SA Duct Liner.
   c. K-Flex USA; Duct Liner Grey.

2. Acoustical Properties: The material shall be tested by an independent testing laboratory to determine the sound absorption coefficient in accordance with ASTM C 423 with ASTM E 795 Type A mounting. The sound absorption coefficients shall meet or exceed the following values:

<table>
<thead>
<tr>
<th>Octave Band Center Frequency Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
</tr>
<tr>
<td>1&quot;</td>
</tr>
</tbody>
</table>

   a. Thickness: 1 inch.
   b. Thermal Conductivity (k-Value): 0.24 at 75 deg F mean temperature.
   c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
   d. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

2.9 ROUND DUCT LINER

A. Provide at locations shown on drawings.

B. General: Comply with applicable requirements of acoustical lining for rectangular ductwork. Do not line underground round ducts.

C. Acoustical Lining: 1" thickness unless otherwise shown. Increase duct dimension for lining. Liner shall be suitable for continuous operation at 4,000 fpm velocity with erosion and shall
conform to UL 723, resistant requirements of NFPA Pamphlet No. 90 and Uniform Mechanical Code. The "R" value shall be 4.3 when tested in accordance with ASTM C518 at 75°F mean temperature.

D. Manufacturer: Manville "Spiracoustic" or approved equal.

E. Acoustical Properties: The material shall meet or exceed the following values using Type "A" mounting in accordance with ASTM C423-81.

<table>
<thead>
<tr>
<th>Octave Band Center Frequency (Hz)</th>
<th>Thickness</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1000</th>
<th>2000</th>
<th>4000</th>
<th>NRC</th>
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<tr>
<td></td>
<td>1&quot;</td>
<td>.13</td>
<td>.28</td>
<td>.64</td>
<td>.88</td>
<td>.97</td>
<td>1.01</td>
<td>.70</td>
</tr>
</tbody>
</table>

2.10 KITCHEN HOOD EXHAUST DUCT

A. Materials.

1. Kitchen hood exhaust ducts shall be constructed of and supported by carbon steel not less than 0.054 in. (No. 16 MSG) in thickness or stainless steel not less than 0.043 in. (No. 18 MSG) in thickness.
2. Factory-built grease ducts listed in accordance with UL 1978 shall be permitted to use materials in accordance with their listing.

B. Openings.

1. Openings shall be provided at the sides or at the top of the duct, whichever is more accessible, and at changes of direction. The entire length of a grease duct needs to be accessible for inspection and cleaning. Openings shall be protected by approved access constructed and installed in accordance with the requirements of the IMC Section 506.
2. For common exhaust duct systems, access panel openings shall be provided for installation and servicing of the fire-extinguishing system.
3. On horizontal ducts, at least one 20 in. × 20 in. opening shall be provided for personnel entry. Support systems for horizontal grease duct systems 24 in. and larger in any cross-sectional dimension shall be designed for the weight of the ductwork plus 800 lb at any point in the duct systems.
4. On vertical ductwork where personnel entry is possible, access shall be provided at the top of the vertical riser to accommodate descent. Where personnel entry is not possible, adequate access for cleaning shall be provided on each floor.

C. Access Panels.

1. Access panels shall be of the same material and thickness as the duct. Access panels shall have a gasket or sealant that is rated for 1500°F and shall be greasetight.
2. Fasteners, such as bolts, weld studs, latches, or wing nuts, used to secure the access panels shall be carbon steel or stainless steel and shall not penetrate duct walls.
3. Access panels in a horizontal duct shall be at least 1-1/2" above the bottom of the duct. Maximum length between access panels is 20 feet. See IMC 506.3.9 for other opening requirements.
4. Listed grease duct access door assemblies (access panels) shall be installed in accordance with the terms of the listing and the manufacturer's instructions.
D. Installation

1. The grease duct shall be installed in accordance with the requirements of the International Mechanical Code section 506 and NFPA 96. All seams, joints, penetrations, and duct-to-hood collar connections shall have a liquidtight continuous external weld except as permitted by the referenced code above. Butt welded connections shall not be permitted.
2. Horizontal ducts shall be graded back to the hood connection for cleaning.
3. Clearance between ducts and combustible materials shall be provided in accordance with the requirements of Section 4 of NFPA 96.

E. Duct Enclosures

1. Where vertical fire barriers are penetrated, the ducts shall be enclosed in a continuous enclosure extending from the first penetrated fire barrier and any subsequent fire barriers or concealed spaces to or through the exterior, to maintain the fire resistance rating of the highest fire barrier penetrated.
2. In all buildings more than one story in height the ducts shall be enclosed in a continuous enclosure extending from the lowest fire-rated ceiling or floor above the hood, through any concealed spaces. Buildings less than four stories in height shall have an enclosure with a fire resistance rating of not less than 1 hour. Buildings four stories or more in height shall have an enclosure with a fire resistance rating of not less than 2 hours. The enclosure shall be vented to the exterior of the building through weather-protected openings. See IMC.3.6.10 for exceptions.
3. The continuous enclosure provisions shall not be required where a field-applied grease duct enclosure or a factory-built grease duct enclosure is protected with a listed duct-through-penetration protection system equivalent to the fire resistance rating of the assembly being penetrated, and where the materials are
4. Clearance from the duct to the interior surface of enclosures of combustible construction shall be not less than 18 in. Clearance from the duct to the interior surface of enclosures of noncombustible or limited-combustible construction shall be not less than 6 in.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Coordination Drawings: Sheet metal duct installation shall be coordinated with other trades prior to installation in order to avoid conflict with the following other building elements:

1. Ceiling suspension assembly members.
2. Systems installed in same space as ducts (piping, electrical conduits, equipment, etc.).
3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Fabricate and install ductwork and accessories in accordance with SMACNA Duct Construction Standards, Metal and Flexible.
1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, terminal units, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide necessary fittings and offsets at no additional cost to the owner. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions, which shall be altered by the contractor to other dimensions with the same air handling characteristics (not less than same free area and pressure drop) where necessary to avoid interferences and clearance difficulties.

2. Comply with the requirements of Section 230500, "Transitions and Offsets Beyond the Scope of Work".

C. Provide Duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Duct Construction Standards, Metal and Flexible and with Duct Fitting Requirements detail on drawings.

1. When an obstruction cannot be avoided and must be taken in by the duct, comply with SMACNA “Obstructions”. Repair galvanized areas with galvanizing repair compound.

2. Construct casings, plenums, eliminators, and pipe penetrations in accordance with SMACNA Standards, Install plenum access doors to swing against air pressure so that pressure helps to maintain a tight seal.

D. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

E. Install ducts with fewest possible joints.

F. Provide test holes at fan inlets and outlets, where required for balancing, and elsewhere as indicated.

G. Install fabricated fittings for changes in directions, size, and shape and for connections.

H. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

I. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

J. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

K. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

L. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

M. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

N. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
O. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

P. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

Q. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Penetration Firestopping."

R. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic force required by applicable building codes. Refer to Division 23, Section 230529, "Hangers Supports & Seismic Controls for Mechanical Components."

S. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

T. New Ductwork Protection and Cleaning:

1. Each piece of shop-fabricated ductwork shall be cleaned of contaminants and oil residue before being sent to the job site.
2. Each piece of field-fabricated ductwork shall be cleaned of contaminants and oil residue. It shall then either be promptly installed or sealed with visqueen or “Ductcap Products Inc” caps and stored.
3. All ductwork stored on the jobsite shall remain sealed until it is installed. Unsealed sections of ductwork shall not be permitted to be stored or lying about the jobsite.
4. All ductwork shall be protected from moisture at all times.
5. All ends of installed ductwork shall be sealed with visqueen or “Ductcap Products Inc” caps at the end of each work day.

U. Ductwork Cleanliness Testing:

1. The Owner or their designated representative will visually observe the metal ducts for oil residue and contaminants. Where contaminants are discovered visually or by a white-glove test, the contractor is responsible for re-cleaning the ductwork before re-evaluation. Notify A/E when the majority of new ductwork has been installed, but before terminal units are connected and again before flexible ducts and diffusers are connected.
   a. If analysis determines that levels of debris are equal to or lower than suitable levels (5.0 mg/m³ of particulates), system shall have passed cleanliness verification.
   b. If analysis determines that levels of debris exceed suitable levels, system cleanliness will have failed and metal duct system shall be re-cleaned and re-tested at Contractor’s expense.
3.2 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure and seal class indicated in Part 2 of this specification section.

B. Seal ducts before external insulation is applied.

C. Adhesive-backed cloth or metallic furnace tape will not be acceptable.

3.3 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."

3.4 installation of sound liner in ducts

A. Round Liner Fastening: Liner shall slip into interior of sheet metal round duct in sections; finish with male/female slip-joints for strong, snug connections between sections.

B. Rectangular Fiberglass Liner:

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 standard liner product dimensions make longitudinal joints necessary. Delete paragraph below if air velocities do not exceed 2500 fpm.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm. Securing method below is for ducts with air velocities of 2500 fpm and less. Use caution when designing lined ducts with air velocities greater than 2500 fpm. Refer to SMACNA for requirements.
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 greater than 2500 fpm or where indicated.
C. Closed-Cell Elastomeric Foam Liner:

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 standard liner product dimensions make longitudinal joints necessary.
6. Secure liner with mechanical fasteners four inches from corners and at intervals not exceeding 12 inches transversely; at three inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
7. 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 greater than 2500 fpm (12.7 m/s) or where indicated.
8. 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.

3.5 FIELD QUALITY CONTROL

A. Air Supply and Distribution Systems: The air supply, return, and exhaust and distribution systems and its components shall be given an operational test.

B. Leakage Testing of Ductwork: Perform the following field test(s) and inspections according to SMACNA "HVAC Air Duct Leakage Test Manual", prepare test reports, and submit for approval. Include final reports in the O&M Manual:

   1. Preliminary duct leakage test is not always required, but is useful in certain project situations
      1. Perform preliminary duct leakage test when ductwork is between 15% and 30% complete. The engineer shall select the section(s) of ductwork to be tested, or may elect to test all installed ductwork.
      2. Perform final duct leakage test of complete system, including supply, return, and exhaust ductwork.
      3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
      4. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, request clarification from the Engineer.
before constructing ductwork. Do not pressurize systems above maximum design operating pressure. Give seven days written advance notice for testing. Testing shall be repeated if conducted without required notice.

5. Maximum Allowable Leakage: Pressure classes refer to both positive and negative in absolute values. Note that some of these requirements exceed default SMACNA leakage class values. Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch w.g., and Leakage Class 6 for pressure classes from above 2-inch to 10-inch w.g.

6. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

3.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233100
SECTION 233300 - AIR DUCT ACCESSORIES

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 the following:
      1. Backdraft dampers.
      2. Volume dampers.
      3. Motorized dampers.
      4. Fire dampers.
      5. Combination fire and smoke dampers.
      6. Duct silencers.
      7. Clean flow duct silencers.
      8. Packless duct silencers.
      9. Duct-mounted access doors.
     10. Casing and Plenum access doors.
     11. Flexible connectors.
     12. Flexible ducts.

   B. Related Sections include the following:
      1. Division 23, Section 230900, "Instrumentation and Control for HVAC" for electric and
         pneumatic damper actuators.
      2. Division 28, Section 283111, "Fire Detection and Alarm" for duct-mounting fire and
         smoke detectors.
      3. Division 23, Section “HVAC Ductwork and Casings” for test ports, stuffing boxes,
         turning vanes, joint sealant, and safety relief access doors.

1.3 SUBMITTALS
   A. Product Data: Submit for the following:
      1. Backdraft dampers.
      2. Volume dampers.
      3. Motorized dampers.
      4. Fire dampers.
      5. Combination fire and smoke dampers.
      6. Duct silencers.
      7. Clean flow duct silencers.
      8. Packless duct silencers.
9. Duct-mounted access doors.
10. Casing and plenum access doors.
11. Flexible connectors.
12. Flexible ducts.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Motorized dampers installation including actuator location and accessibility.
3. Fire-damper, smoke-damper, and combination fire and smoke damper installations, including sleeves and duct-mounting access doors.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE


PART 2 - PRODUCTS

2.1 SHEETMETAL MATERIALS

A. Galvanized Steel: Steel sheets, G-60 zinc-coated (galvanized) or zinc-iron alloy coated (galvannealed) by the hot dip process, conforming ASTM A653 unless noted otherwise.


1. Rectangular Ductwork: Aluminum ductwork shall comply with the requirements of low pressure galvanized steel ductwork. Thickness adjustments of aluminum, including dimension adjustments and reinforcements needed to meet the construction requirement thickness of steel ducts, shall comply with SMACNA 2005 HVAC Duct Construction Standards, Article 2.10.1, "Conversion of Steel Tables to Aluminum".

2. Round Ductwork: Construction of aluminum duct and fittings shall otherwise correspond in the same relationship as for steel duct. Conform to SMACNA 2005 HVAC Duct Construction Standards, Table 3-14, "Aluminum Round Duct Gage Schedule". Aluminum fasteners shall be used. Structural members shall be alloy 6061-T6 or galvanized steel as related in SMACNA for rectangular duct. Hangers in contact with the duct shall be galvanized steel or aluminum.

C. Stainless Steel: Unless indicated otherwise, Type 316L stainless steel, not to exceed 0.03% carbon, conforming to ASTM A240/A240M.
2.2 BACKDRAFT DAMPERS

A. Basis of Design: Ruskin Model CBD6.

B. Manufacturers:
   1. Ruskin Model CBD6
   2. Air Balance, Inc.
   3. American Warming and Ventilating.

C. Description: Multiple-blade, low-leakage, parallel action gravity balanced, with blades of maximum six-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, molded synthetic bearings, and axles; adjustment device to permit setting for varying differential static pressure. Counterbalances shall be on rear of blades for weather resistance.

D. Frame: 0.125-inch-thick extruded aluminum, with welded corners.

E. Blades: 0.070-inch-thick aluminum sheet with ½” tie bar linkage

F. Blade Seals: Extruded vinyl.

G. Return Spring: Adjustable tension.

H. Performance: Damper shall withstand a 3” water gauge pressure differential. Maximum leakage shall be 17.5 cfm/sf or less measured on 24” wide damper at a 1” w.g. differential pressure. Blade shall fully open at 0.05” w.g. Damper pressure drop shall be less than 0.1” w.g. at 1200 fpm.

I. Backdraft Dampers in Fume Exhaust Ducts: Stainless steel, same as fume duct. Gauge same as fume duct.

2.3 VOLUME DAMPERS

A. General Description: All volume dampers shall be factory fabricated with hardware and accessories. Stiffen damper blades for stability and include locking device to hold single-blade dampers in a fixed position without vibration. Dampers shall be free from any sharp edges that would produce excessive turbulence. Dampers must be rated for the service pressure drop, velocity, and temperature.

B. Damper and Accessory Material: Same as metal duct.

C. Single Blade Volume Dampers:
   1. Permitted only for rectangular ducts up to 36” wide and 12” high or round ducts up to 12” diameter.
   2. Use the Opposed-Blade dampers, orifice plates, or a high-pressure drop fitting in lieu of this damper for higher velocity and pressure-drop applications (for example, upstream of a terminal box that is close to the fan).
   3. Rated for velocities up to 1500 fpm and pressure drops across damper of 1 in. w.g. or less.
4. Damper blade shall be minimum 22-gauge steel and shall be as close to full size as possible without binding. Both leading and leaving edges hemmed; side edges flanged 1/2"; placed so air strikes the smooth face.
5. Damper shaft shall be minimum 3/8” square rod. Shafts shall be full length.
6. Frame shall be min. 20-gauge steel channels with mitered and welded corners.
8. Manufacturers:
   b. Greenheck Models MBD-10 and MBDR-50
   c. Ruskin
   d. Young Regulator Company

D. Rectangular and Square Opposed-Blade Volume Dampers:
1. You must designate on the drawings that this damper style is required for high velocity or pressure drop situations, unless the duct size is greater than 36” wide or 12” high.
2. Provide for rectangular ducts over 36” wide or 12” high or round ducts over 12” diameter and where specifically designated on the drawings.
   a. May be used in place of single blade volume dampers at contractor’s option.
   b. Rated for velocities up to 2000 fpm and pressure drops across damper of 2 in. wg. or less.
   c. Damper must be rated for the service pressure drop, velocity, and temperature.
3. Round ducts shall be provided with transitions into and out of the square damper assembly.
4. Damper blades shall be minimum 16-gauge galvanized steel. Both leading and leaving edges hemmed; side edges flanged 1/2”; placed so air strikes the smooth face.
5. Damper shafts shall be minimum 1/2” square rod. Shafts shall be full length.
6. Frames shall be min. 16-gauge galvanized steel structural or formed channels with mitered and welded corners.
8. Manufacturers:
   a. McGill AirFlow Corporation Model UVC21
   b. Greenheck Model VCD-18
   c. Ruskin
   d. Young Regulator Company

E. Bearings:
1. Provide end bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
2. Bearings shall be molded synthetic, oil-impregnated bronze, Zytel, or stainless steel.
4. Manufacturers:
   a. Ventfabrics HiVel Ventlok
   b. Young Regulator Company
F. Quadrants:

1. Provided with a dial regulator, heavy gauge handle, and locking nut. Size to match shaft size.
2. Provide elevated stand-off for use on all externally insulated ductwork.
4. Manufacturer:
   a. Ventfabs Ves Quadrant
   b. Young Regulator Company

G. Quadrants for Dampers in Ducts Concealed Behind Walls and Above Non-Removable Ceilings:

1. Alert architect that these will be required. Verify that field painting is appropriate or if other options, (like chrome plating) are better. You may also want to specify labeling for which damper is served.
2. Direct Controlled Dampers: Where possible, use direct controlled dampers. Damper regulator shall be cast into a box for flush mounting in ceilings. Cover telescopes into base to allow for expansion. Cover shall be secured by two screws to facilitate removal for adjustment of the damper. The regulator shall be made to accommodate 3/8" and 1/2" square rod.
   a. Basis of Design: Young Regulator No. 301
   b. Manufacturers:
      1) Young Regulator No. 301
      2) Ventfabs No. 666
      3) Ruskin
      4) Nailor
3. Cable Controlled Dampers: Balancing dampers in ducts concealed behind walls and non-removable ceilings shall be provided with cable-controls if access to the regulator cannot be immediately adjacent to the damper. Damper controller and cable shall be concealed above the ceiling. Cable shall consist of Bowden cable 0.054" stainless steel control wire encapsulated in 1/16" flexible galvanized spiral wire sheath. Control kit shall consist of 2-5/8" diameter die cast aluminum housing with three-inch diameter cover, and 14-gauge steel rack and pinion gear drive converting rotary motion to push-pull motion. Control kit shall be imbedded in the ceiling flush with the finished surface. Control kit shall be manually operated with a wrench.
   a. Basis of Design: Young Regulator Model 270-301 control kit and Model 030-12 wrench
   b. Manufacturers:
      1) Young Regulator Model 270-301 control kit and Model 030-12 wrench.
      2) Ventfabs
2.4 MOTORIZED DAMPERS

A. Control Dampers: AMCA-rated, opposed blade design; 0.125-inch minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall be heavy gage extruded aluminum, airfoil type, with maximum blade width of 6 inches and length of 48 inches.

1. Secure blades to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, blade-linkage hardware of zinc-plated steel and brass, ends sealed against molded synthetic blade bearings.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Low-Leakage: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 8 cfm per sq. ft. of damper area at differential pressure of four-inch w.g. and a maximum of 3 cfm per sq ft at one-inch w.g. when tested according to AMCA 500D.

B. Large damper assemblies shall be made of individually driven segments that are small enough to ensure reliable operation and uniform closure across the entire damper assembly. Actuators shall be operated independently so that if one damper segment or actuator becomes inoperable, the others remain operable (provide multiple end switches wired together so if a section fails, end switch will acknowledge). Jack shafts and linkages should not be necessary and can only be used if approved by Owner.

C. See the failure mode section above for actuator responses under failure due to loss of power, loss of control air, or loss of communication. Where an actuator is to fail open or fail closed, provide spring return. Actuators shall not be dependent on batteries or capacitors to stroke to the power fail position upon loss of power.

D. Permanently stamp or scribe position indication on the end of driven shaft unless damper is visible from same location as end of shaft.

E. Actuators: See Section 230900 - INSTRUMENTATION AND CONTROL SYSTEMS.

F. Manufacturer: Ruskin, American Warming and Ventilation or approved equal dampers.

1. Control damper - Ruskin Industries Model CD50
2. Smoke damper - Ruskin Industries Model SD50,

2.5 FIRE DAMPERS

A. Basis of Design: Ruskin Company model DIBD2 Style B and DIBD23 Style B.

B. Manufacturers:

1. Ruskin Company model DIBD2 Style B and DIBD23 Style B.
2. Air Balance
3. Greenheck
4. Nailor Industries

C. Fire dampers shall be labeled according to UL 555, and NFPA 90-A. Dampers shall be factory fabricated and rated for 1-1/2 hours (DIBD2) and 3 hours (DIBD23).
D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 20-Ga. galvanized steel; with mitered and interlocking corners. Horizontal damper mullions and head boxes are not permitted.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
   1. Minimum Thickness: 0.052 or 0.138-inch-thick as required for listing and of length to suit application.
   2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

F. Mounting Orientation: Vertical or horizontal as indicated.


H. Horizontal Dampers: Include stainless steel closure spring.

I. Fusible Links: Replaceable, 165-degree F rated.

J. Round or flat oval dampers shall be provided with collar for connection to duct and breakaway connection at housing.

K. Dampers shall have not less than 90% free area for rectangular ducts and 100% free area for round and flat oval ducts. Manufacturer shall coordinate with contractor as to whether the height and/or width will be increased beyond the duct size to meet this requirement. See table below for dampers up to 1450 fpm.

<table>
<thead>
<tr>
<th>Duct Height</th>
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2.6 COMBINATION FIRE AND SMOKE DAMPERS

A. Basis of Design: Ruskin Company Model FSD60 (Rectangular Ducts) or Model FSDR25 (Round or Oval Duct)

B. Manufacturers:
   1. Ruskin Company Model FSD 60 (Rectangular Ducts) or Model FSDR25 (Round or Oval Duct).
   2. Air Balance, Inc.
   3. Greenheck
   4. Nailor Industries

C. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating. Linkage shall be concealed in frame.

D. Dampers shall be Leakage Class I. Dampers in ducts smaller than 12” x 12” shall be Leakage Class II.

E. Reusable, Resettable Links: Each combination fire smoke damper shall be equipped with a factory installed heat responsive device rated to close the damper when the temperature at the damper reaches 165-degree F.

Specify stainless-steel dampers (304 or316L) for fume exhaust ductwork and confirm availability from each manufacturer. Not all carry 316L.

F. Frame: Min. 16 Ga. thick galvanized hat channel or min. 13 Ga. galvanized channel.

G. Blades: Min. 14-Ga thick, galvanized sheet steel, horizontal, airfoil style. Provide silicone edge seal, mechanically locked to blade edge.

H. Bearings: Self-lubricating stainless-steel sleeve turning in an extruded frame hole.

I. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.

J. Dampers shall have not less than 90% free area for rectangular ducts and 100% free area for round and flat oval ducts. Manufacturer shall coordinate with contractor as to whether the height and/or width will be increased beyond the duct size to meet this requirement. See table below for dampers up to 1450 fpm.

<table>
<thead>
<tr>
<th>Duct Height</th>
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K. Electric Actuators: Appropriate electric actuators, two-position, 120 VAC, for tie in to smoke detection system shall be installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and actuators. Damper and actuator assembly shall be factory cycled 10 times to assure operation. Actuators shall always move toward the full-open position when energized and always move toward the full-closed position when not energized. This requirement shall not be compromised by any combination of short-term power pulses.

L. Pneumatic Actuators: Appropriate pneumatic actuators, two-position, shall be installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity that meets all applicable UL555 and UL555S qualifications for both dampers and actuators. Provide an EP relay (24V electric-pneumatic) factory mounted with tubing to the heat closure device and actuator. Damper and actuator assembly shall be factory cycled 10 times to assure operation.

2.7 CLEAN FLOW DUCT SILENCERS

A. Rectangular Units:
   1. Fabricate casings with a minimum of 0.034-inch- thick, solid galvanized sheet metal for outer casing and 0.022-inch- thick, ASTM A 653/A 653M, G60, perforated galvanized sheet metal for inner casing.
   2. Basis of Design: Industrial Acoustics Company “Quiet Duct”, Type HS or as specified.
   3. Manufacturers:
      a. Industrial Acoustics Company
      b. Vibro-Acoustics
      c. Dynasonics
      d. VAW Systems

B. Schedule performance on the drawings. Include pressure drop for ideal conditions and for actual installation conditions taking into account actual inlet and outlet duct configurations and conditions.

C. Round Units:
   2. Manufacturers:
      a. Industrial Acoustics Company Ruskin Company
b. Vibro-Acoustics
c. Dynasonics

3. Outer Casings:
   b. Up to 24 Inches in Diameter: 0.034 inch thick.
   c. 26 through 40 Inches in Diameter: 0.040 inch thick.
   d. 42 through 52 Inches in Diameter: 0.052 inch thick.
   e. 54 through 60 Inches in Diameter: 0.064 inch thick.
   f. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.

4. Interior Casing, Partitions, and Baffles:
   b. At least 0.034-inch-thick and designed for minimum aerodynamic losses.

D. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

E. Fill Material: Inert and vermin-proof fibrous material, packed under not less than five percent compression or Moisture-proof nonfibrous material. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.

F. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.

G. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
   1. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
   2. Lock form and seal or continuously weld joints.
   3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
   4. Reinforcement: Cross or trapeze angles for rigid suspension.

H. Source Quality Control:
   1. Static pressure loss of the silencers shall not exceed 0.3” and the values listed in the sound attenuator schedule at the airflow indicated.
   2. Acoustic Performance: Testing must be performed by an independent laboratory according to ASTM E 477 and must meet or exceed the performance listed in the sound attenuator schedule.
   3. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm face velocity.
   4. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.
2.8 PACKLESS DUCT SILENCERS

A. Schedule performance on the drawings. Include pressure drop for ideal conditions and for actual installation conditions taking into account actual inlet and outlet duct configurations and conditions. Cost is about twice that of media attenuators. Specify stainless steel, continuously welded casings for fume hood exhaust systems.

B. Basis of Design: Industrial Acoustics Company “Ultra-Pals Packless Silencers”, Type as specified.

C. Manufacturers:

1. Industrial Acoustics Company “Ultra-Pals Packless Silencers”, Type as specified.
3. Dynasonics.
4. VAW Systems

D. Materials:

1. Unless otherwise specified, the silencers shall be constructed of Type #G-90 lockformer quality galvanized steel. The silencer casings shall be a minimum of #22 Gauge solid galvanized steel. The internal partitions shall be a minimum of #26 Gauge perforated galvanized steel.
2. No sound absorptive material of any kind shall be used in the silencers. The silencers shall attenuate air-transmitted noise solely by virtue of controlled impedance membranes and broadly tuned resonators.

E. Construction:

1. Units shall be constructed in accordance with the ASHRAE Guide recommendations for high-pressure ductwork. Seams shall be lock formed and mastic filled. Rectangular casing seams shall be in the corners of the silencer shell to provide maximum unit strength and rigidity. Interior partitions shall be fabricated from single-piece, margin perforated sheets and shall have die-formed entrance and exit shapes to provide the maximum aerodynamic efficiency and minimum self-noise characteristics in the sound attenuator. Blunt noses or squared off partitions will not be accepted.
2. The interior partitions shall be attached to the casing by means of an interlocking track assembly. Tracks shall be solid galvanized steel and shall be welded to the outer casing. Attachment of the interior partitions to the tracks shall be such that a minimum of four thicknesses of metal exist at this location.
3. The track assembly shall stiffen the exterior casing, provide a reinforced attachment detail for the interior partitions, and shall maintain a uniform airspace width along the length of the silencer for consistent aerodynamic and acoustic performance.
4. Sound attenuating units shall not fail structurally when subjected to a differential air pressure of 8" W.G. from inside to outside the casing.

F. Acoustic Performance:

1. Silencer ratings shall be determined in a duct-to-reverberant room test facility, which provides for airflow in both directions through the test silencer in accordance with ASTM Specification E-477. The test facility shall be NVLAP accredited for the ASTM E477 test
standard. Data from a non-accredited laboratory will not be acceptable. The test set-up and procedure shall be such that all effects due to end reflection, directivity, flanking transmission, standing waves and test chamber sound absorption are eliminated.

2. Acoustic ratings shall include Dynamic Insertion Loss (DIL) and Self-Noise (SN) Power Levels both for Forward Flow (air and noise in same direction) and Reverse Flow (air and noise in opposite directions) with airflow of at least 1000 fpm entering face velocity. Data for rectangular silencers shall be presented for tests conducted using silencers no smaller than the following cross-sections: 24"x24", 24"x30", or 24"x36".

G. Aerodynamic Performance:

1. Static pressure loss of the silencers shall not exceed 0.3" and the values listed in the sound attenuator schedule at the airflow indicated.
2. Airflow measurements shall be made in accordance with ASTM specification E 477 and applicable portions of ASME, AMCA, and ADC airflow test codes.
3. Airflow data shall be reported on the identical units for which acoustic data is presented.
4. Airtight construction where required shall be provided by use of a duct sealing compound on the job site, material and labor furnished by the contractor.

H. Certification: With submittals, the manufacturer shall supply certified test data on Dynamic Insertion Loss, Self-Noise Power Levels, and Aerodynamic Performance for Reverse and Forward Flow test conditions. Test data shall be for a standard product. All rating tests shall be conducted in the same facility, shall utilize the same silencer, and shall be open to inspection upon request from the A/E.

I. Duct Transitions: When transitions are required to adapt silencer dimensions to connecting duct work, they shall be furnished by the installing contractor.

2.9 DUCT-MOUNTED ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Rectangular Duct Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

2. Manufacturers:
   b. Air Balance Inc. “Series FSA”
   c. Greenheck
   d. McGill AirFlow Corporation Model ARB
   e. Ruskin “SMACNA Standard”

3. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
4. Provide number of hinges and locks as follows:
a. Less Than 12 Inches Square: Secure with two sash locks.
b. Up to 18 Inches Square: Two hinges and two sash locks.
c. Up to 24 by 48 Inches: Three hinges and two compression latches.
d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Round Duct Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

2. Manufacturers:
   a. Ductmate Industries, Inc. “Sandwich Access Door”
   b. McGill AirFlow Corporation


D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

E. Insulation: One-inch- thick, fibrous-glass or polystyrene-foam board.

2.10 Access Doors in Casings and Plenums:

A. Construct in accordance with SMACNA 2005 HVAC Duct Construction Standards, Fig. 9-16. Doors shall be double-wall insulated type and shall be equipped with three heavy duty zinc plated steel strap type T-hinges and two latches with lever handle on outside and inside. Doors shall be gasketed.

2. Manufacturers:
   a. Ductmate Industries, Inc
   b. Ventfabrics, Inc. "Ventlok"
   c. Air Balance, Inc. Series FSA

B. Latches shall have lever handle and stud to accommodate door thickness with inside beveled flange to work against door frame to give compression. Latch escutcheon shall be sponge rubber gasketed, heavy duty zinc plated steel

C. Walk-in access doors in casing and plenum walls shall be minimum 20" x 72" size.

2.11 FLEXIBLE CONNECTORS

A. Basis of Design: Ductmate Industries, Inc. “Proflex”.

B. Manufacturers:
   1. Ductmate Industries, Inc. “Proflex”
   2. Ventfabrics, Inc. “Ventglas” (Indoor Installations) and “Ventlon” (Outdoor Installations).
   3. Duro Dyne Corp.
C. General: Provide fabric-type flexible connectors between fans and ducts or casings, fans and
plenums, and where ducts are of dissimilar metals, as indicated and where required. Fabric
shall comply with UL Standard 214 and shall be accepted by NFPA for vibration isolation
connectors in duct systems per NFPA Standard 90.

D. Connectors at Indoor Installations: Connectors shall be made of heavy glass fabric double-
coated with neoprene, weighing approximately 30 oz. per square yard. Flexible connections
shall be securely fastened by zinc-coated iron cinch-type draw bands for round ducts. For
rectangular ducts, the flexible connections locked to metal collars shall be installed using
normal duct construction standards and according to SMACNA 2005 HVAC Duct Construction
Standards.

E. Connectors at Outdoor Installations: Connectors shall be same as specified for indoor
installations except fabric shall be made of heavy glass fabric double-coated with Hypalon,
weighing approximately 26 oz. per square yard.

2.12 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc. 1M or approved.

B. General: Flexible duct, including connectors, shall comply with UL181, Class I, and NFPA
90A and shall have acoustical performance acceptable to the Engineer. Installed duct shall not
erode, delaminate or impart loose fibers or odors into the air stream. Internal positive working
pressure shall be +10 in. w.g. Internal negative working pressure shall be -5 in. w.g. through
16" diameter and -1 in. wg. at 18" and 20" diameter.

C. Materials: Flexible duct assembly shall consist of a strong and puncture resistant polyethylene
inner liner and a high strength duct wall, mechanically locked together with a corrosive
resistant galvanized helix to form a solid performing UL-181, Class 1 flexible duct, without the
use of glue or adhesives.

D. Insulation and Vapor Barrier: The factory-fabricated flexible duct shall have blanket-type
insulation, having a C Factor of not more than 0.23. The insulation shall be sheathed with a
reinforced metallized vapor barrier having a maximum permeability of 0.05 perm per ASTM
E96, Procedure A. The vapor barrier jacket on the flexible duct shall be sealed to vapor barrier
on the connecting sheet metal ducts. Joints shall be airtight slip joints sealed and secured with a
clamp.

E. Clamps: 175-lb test 6/6 nylon locking draw band at each end.


F. Acoustical Performance: Test reports from an independent laboratory showing that flexible
ducts meet the performance specifications stated below. If manufacturer other than that
specified is submitted, provide acoustical performance ratings for each size flexible duct.
Acoustical performance testing shall be performed by an independent laboratory. The specified
insertion loss and radiated noise reduction of flexible duct should be met when tested with a 6-
foot length of straight duct less than 500 feet per minute velocity.
**Type 1M INSERTION LOSS (dB)**

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<th>Air Velocity</th>
<th>Octave Band Center Frequency (Hz)</th>
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**Type 1M INSERTION LOSS WITH 90 DEG. ELBOW (dB)**

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<th>Air Velocity</th>
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**PART 3 - EXECUTION**

3.1 **APPLICATION AND INSTALLATION**

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible".

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel except when another material is specifically specified (Example: aluminum made damper in galvanized duct), stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. **Volume Dampers:**

1. Contractor shall set and lock all dampers in the "Full Open" position prior to balancing work.
2. Mount volume damper quadrants and end bearings so that the fasteners do not limit full damper travel.
3. Provide volume dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing.

4. Install volume dampers as far from the outlet as possible while maintaining at a minimum of two duct widths from branch takeoff. Install at a point where the duct is accessible, if possible; axis of the blade the long dimension.

D. Backdraft Dampers: Install on all exhaust fans or exhaust ducts nearest to outside that are not specified to have automatic dampers and elsewhere as indicated.

E. Fire and Smoke Dampers:

1. Install with fusible links, according to manufacturer's UL-approved written instructions to conform to the installation used for the rating test.

2. Leave dampers in full open position.

3. Inspect areas to receive dampers. Notify engineer of conditions that would adversely affect the installation or subsequent utilization of the dampers. Do not proceed with installation until unsatisfactory conditions are corrected.

4. Dampers must be accessible to allow inspection, adjustment, and replacement of components. The installing contractor shall furnish access doors in ductwork or plenums to provide this access for inspection, repair and cleaning.

5. The fire dampers and combination fire/smoke dampers are specified to have not less than 90% free area. Provide suitable duct transitions to accommodate damper collar size. Duct transitions shall comply with SMACNA 2005 HVAC Duct Construction Standards and the duct fittings/transition legend on the drawings.

6. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

7. Contractor shall locate dampers on "as-built" drawings.


9. TDC/TDF joints may not be connected to the rough edge of a fire damper to form a break-away connection.

F. Duct Silencers: Install rigidly to ducts. Maintain straight duct upstream and downstream of silencer, as shown on plans, to achieve actual installed pressure drop listed in equipment schedule.

G. Access doors are required, but not typically shown on the drawings.

1. Install duct access doors on side of duct to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

   a. Upstream of duct mounted coils, smoke detectors, and humidifiers.
   b. Adjacent to back draft dampers, providing access to adjust counterbalances.
   c. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
   d. Adjacent to automatic control dampers.
   e. At turning vanes in return and exhaust ductwork.
   f. For cleaning operating room supply air duct and kitchen hood exhaust duct, locate access doors at 20-foot intervals and at each change in duct direction.
2. Sizes below are from one manufacturer's literature. SMACNA lists only three sizes, 12 by 12 inches (300 by 300 mm), 16 by 20 inches (400 by 500 mm), and 24 by 24 inches (600 by 600 mm) but makes no recommendations for applications.

3. Install the following sizes for duct-mounting, rectangular access doors:
   
a. One-Hand or Inspection Access: 8 by 5 inches.
b. Two-Hand Access: 12 by 6 inches.
c. Head and Hand Access: 18 by 10 inches.
d. Head and Shoulders Access: 21 by 14 inches.

4. Install the following sizes for duct-mounting, round access doors:
   
a. One-Hand or Inspection Access: 8 inches in diameter.
c. Head and Hand Access: 12 inches in diameter.
d. Head and Shoulders Access: 18 inches in diameter.

5. Label access doors according to Division 23, Section 230553, "Identification for HVAC Piping and Equipment."

H. Flexible Connectors:

1. Install immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
   
2. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

I. Flexible Ducts:

1. Refer to SMACNA 2005 Standards, Chapter 3. Ducts shall be continuous, single piece at least 6 and no more than 8 feet long. Ducts shall have at least one, but not more than two, 90° elbows. Centerline radius of bends shall be not less than two duct diameters. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor penetrations fire rated one hour or two hour.
   
2. Comply with SMACNA support standards and the requirements below.
   
a. Provide 2" wide sheet metal or "Saddle-Strap" non-metallic strap hangers maximum four feet on center. More frequent supports may be required to meet sag limitation.
b. Maximum permissible sag is 1/2" per foot of spacing.
c. Hangers shall be adequately attached to the building structure. Do not attach hangers to piping, ducts, or conduit.
3.2 INSTALLATION-devices furnished under other sections

A. Motorized Dampers: Install all motorized dampers. Coordinate best location prior to ductwork fabrication and provide damper-manufacturer recommended straight duct length upstream and downstream. Dampers in ductwork and in plenums shall be provided with sheet metal closures all around the dampers frame, including mullions. Seal perimeter of damper frame closures with fire-retardant mastic for airtight closure. Construction and airtightness must be suitable for duct pressure class used. Multiple damper sections shall be bolted together and reinforced at joints with steel angles or channel mullions.

B. Smoke Detectors: Install all smoke detectors furnished by the control contractor or electrical contractor. Review smoke detector submittals and advise manufacturer of anticipated air velocity range. Coordinate best location prior to ductwork fabrication and provide detector-manufacturer recommended straight duct length upstream and downstream. Provide adequate clearance for service and removal.

C. Field-Installed Mixing Damper Installation:
   1. Install mixing dampers specified as part of this section or as furnished by others.
   2. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
   3. Assemble multiple sections of dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
   4. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
   5. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

D. Air Flow Measuring Devices:
   1. Install units specified as part of this section or as furnished by others.
   2. Install with minimum straight run distances, upstream and downstream as recommended by the manufacturer. Notify engineer at submittal time if required distances do not appear to be sufficient.

3.3 EQUIPMENT AND MATERIALS PROTECTION

A. Adequately protect equipment and materials against physical damage. Place equipment and materials in first class operating condition or return to source of supply for repair or replacement, as determined by the engineer. Protect all equipment and materials from moisture at all times. Protect during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

3.4 TESTING

A. Combination Fire Smoke Damper Tests: After installation, all combination fire smoke dampers and all associated controls shall be tested to prove correct control, installation and that damper blades move freely within the confines of the damper frame and do not slip on their shafts.
Contractor shall submit a signed statement in O&M Manuals certifying all dampers to be operational.

3.5 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23, Section 230593, "Testing, Adjusting, and Balancing for HVAC."

3.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233300
SECTION 233400 - HVAC FANS

PART 1 - GENERAL

1.1 PERFORMANCE REQUIREMENTS

1.2 SUBMITTALS

A. Product Data: Submit for each type of product indicated. Submit product information on all air handling units, including fan curves, motor data, coil data, filter data, control damper data, pressure drops for individual components/sections, total static pressure drop, vibration transmission data, and sound power levels in all octave bands at midfrequencies.

B. Shop Drawings: For each fan, Include plans, elevations, sections, details, and attachments to other work.
   1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
   4. Wiring Diagrams: For power, signal, and control wiring.
   5. Operation and maintenance data:

1.3 QUALITY ASSURANCE

A. Single Source Responsibility: Comply with the requirements specified in Division 1.

B. Standardization: Provide air-handling units of the same manufacturer throughout where possible.

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.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.
1.5 WARRANTY

A. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 AIR MOVING EQUIPMENT—GENERAL REQUIREMENTS

A. Criteria:

1. Performance data for all fans shall be determined in accordance with the provisions of AMCA Standard 210.
2. Sound power level ratings of ducted fans shall comply with AMCA Standard 330 and shall be the results of tests made in accordance with AMCA Standard 300.
3. Unit construction shall conform to applicable standards contained in AMCA Standard Handbook Publications and to requirements specified herein.

B. Safety: Safety provisions for power transmission equipment and non-ducted fan inlets and outlets shall include guards and screens, unless other provisions are required, and constructed in accordance with applicable provisions of ANSI/ASME B15.1, the recommendations of the National Safety Council and requirements specified herein. Safety provisions shall not present obstacles to measurement of driver and driven shaft speeds with revolution counter. Installation shall be such that fan vibration isolation provisions are not negated.

C. Nameplate: Provide a metallic, corrosion-resistant, embossed or stamped nameplate for each fan. Nameplate data shall include selection point capacity conditions, rpm and bhp. Permanently affix in a conspicuous location.

D. Horsepower: Motor brake horsepower input to each proposed fan shall not exceed scheduled brake horsepower.

E. Alignment: All fan wheels shall be statically and dynamically balanced. Fans shall be properly protected during shipment so that bearings are not damaged.

F. Rigging: Field-rigging methods shall not negate balancing. Lifting eyes shall be used. Shafts shall not be bent.

G. Bearings:

1. Bearings shall be heavy-duty self-aligning foot-mounted ball or roller pillow block type. Bearings shall have a certified ANSI/AFBMA L10 minimum rated life of 80,000 hours unless otherwise specified. Bearings shall have dust-tight seals suitable for lubricant pressures encountered. housings shall be cast iron, unless otherwise specified or approved.

2. Bearings shall be grease lubricated. Lubrication provisions shall be such as to preclude overheating due to excess lubricant or seal blowout due to excess pressure. Grease supply fittings shall be surface ball check type. Provide manual or automatic grease pressure relief fittings as necessary to comply with specified requirements. Bearing and seal construction permitting, relief fittings shall be located on the side opposite to the
supply fitting. Relief shall be visible from normal maintenance locations. Lubrication provisions shall include extension tubes where necessary to facilitate safe maintenance while equipment is operating.

3. Permanently sealed pre-lubricated antifriction bearings, which conform to above-specified materials and ANSI/AFBMA L10 life requirements, may be provided for air moving equipment with nameplate horsepower requirements less than 1/2 in lieu of relubricable bearings.

2.2 FAN DRIVES AND GUARDS

A. Drives: Provide a V-belt drive, with guard, for each fan except direct-driven type fans.

B. Provide speed controller for direct drive fans.

C. Replacement of Existing Drives: Provide all fan drive changes at existing fans to accommodate the revisions to existing air quantities as required by the alteration work and as shown. Drive changes shall be closely coordinated with air balancing work specified in Section 2305, "Testing, Adjusting, and Balancing".

D. Multiple Belt Drives: For all systems with motors 2 hp and larger, drives shall be multiple belt type.

E. Horsepower Ratings of Drives: Select drives in accordance with the following except the minimum drive rating shall be 140% of the motor rating, unless specified otherwise.

   1. Motors 5 HP and Smaller: Adjustable motor sheave, drive 150% of fan brake horsepower at design.
   2. Motors 7-1/2 HP through 30 HP: Fixed motor sheave, drive 145% of fan brake horsepower at design.
   3. Motors Larger Than 30 HP: Fixed motor sheave, drive 140% of fan brake horsepower at design.

F. Drive Sheaves:

   1. Sheaves shall be cast iron, groove pattern suitable for belts selected. Sheaves for two-belt drives on motors 5 hp and smaller shall be adjustable pitch type. Manufacturer: Fort Worth, T.B. Woods Sons, Dodge, Browning, or Worthington.
   2. Minimum Pitch of Motor Sheaves: 4.0" for Type A belts; 6.0" for Type B; 10.0" for Type C; 4.5" for 3/8" width, 9.0" for 5/8" width.
   3. Balancing: For supply fans, fan and motor sheaves shall be balanced both statically and dynamically at full speed at the factory.
   4. Drive ratio shall give the required CFM at the static pressure of the system. In case the static pressure in any system is found to differ from that shown, change the ratio as required. Actual drives shall be to the present capacities shown.
   5. [Submit selection of future drive details for ultimate capacities shown.]

G. Drive Belts: Select for A, B or C cross-section series, or 3/8", 5/8" or 1" width series. Belts shall be imprinted with the manufacturer's name and number identification. Minimum quantity of belts: two per drive. Manufacturer: Uniroyal, Dodge, Dayco, Goodyear, or Gates.
H. Setting of Belt Tension: Adjust belt tensions according to belt manufacturer's recommendations. When adjusted, there shall not be any audible belt slippage during fan acceleration from standstill to operating rpm, or during running of fan.

I. Guards:

1. Guards for each fan drive, except utility set type fans for which the guards are specified with the fan, shall be four-sided guards and shall also cover exposed parts of fan shafts. Size of guards shall also accommodate ultimate capacities shown.
2. Guards shall meet safety standards of AMCA 410, OSHA. Guards shall be provide with 1/2" mesh No. 14-gauge screen in steel angle frame; removable by unbolting sections of the guard for ease of belt replacement; supported on upper isolated base, or from the fan; shall not transmit vibration from fan or motor to the building structure.
3. Size of guards shall be adequate for present fan speed and also for future increased fan speeds where two speeds are shown.
4. Guards for roof-mounted fans shall be solid galvanized steel panels, 20-gauge minimum with screen over midsection of top and bottom of belts for inspection and shall be weathertight construction.

2.3 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
3. Provide electronically commutated motors or motors with 70% motor efficiency.

2.4 CENTRIFUGAL FANS-AIRFOIL and BACKWARD INCLINED TYPES

A. General: Provide the airfoil and backward inclined fans where shown on the drawings; size, arrangement, and capacity as indicated. Motor horsepower and outlet velocities shall not be exceeded. Airfoil and backward inclined fans shall be AMCA Certified for both Air and Sound Performance. Only AMCA Certified fans are acceptable.

B. Basis of design: Greenheck Series 21

C. Manufacturer:

1. Greenheck Series 21
2. Cook CA/CF
3. Twin City Series BA/BC
4. Car-Mon

D. Wheels and Housings: The wheel diameters and discharge areas shall be in accordance with the standard sizes adopted by AMCA for non-overloading fans. Wheels shall be the efficient,
non-overloading airfoil or backward inclined types only. Inlets shall be fully streamlined and housings shall be suitably braced to prevent vibration or pulsation. Housings shall be constructed of heavy gauge steel and shall be continuously welded throughout. The standard coating shall be durable and heat resistant up to 500°F.

E. Shaft and Bearings: The first critical shaft speed of Class I or II fans shall be at least 125% of the fan’s maximum operating speed. The first critical shaft speed of Class III or IV fans shall be at least 142% of the fan’s maximum operating speed. Bearings shall be designed for heavy duty service with a minimum L10 life of 80,000 hours. Bearings ratings shall be based on the fan’s maximum cataloged operating speed. Bearings shall be heavy duty, either single row ball or double row spherical roller type in a one-piece cast iron housing, or a double row spherical roller type in a split cast iron pillowblock. Bearings shall be rigidly supported on heavy structural supports.

F. Spark Resistant Construction: Fan shall be constructed so that the wheel, impeller, or shaft will not permit two ferrous parts of the fan to rub or strike. Where fan is used for temperatures greater than 250°F, wheels shall be constructed of copper. Bearings shall not be placed in the air stream.

G. Split Housings: To facilitate handling, fan shall be furnished with split housing construction. The scroll section shall be bolted together and can be easily separated for cleaning or repair. Fans shall be split vertically or horizontally and may have pie splits for wheel removal or they can be split into three sections as indicated.

H. Performance: Fan performance shall be based on tests conducted in accordance with AMCA Standard Test Code for Air Moving Devices. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics shall be truly non-overloading and shall reach a peak in the normal selection area. Fan manufacturer shall provide sound power ratings in the eight octave bands which shall be based on AMCA Standard 300, test set up No. 1. Sound power ratings shall be in decibels referenced 10-12 watts.

2.5 TUBULAR IN-LINE CENTRIFUGAL FANS

A. General: Provide the inline centrifugal fans where shown on the drawings; size, arrangement, and capacity as indicated. Motor horsepower and outlet velocity shall not be exceeded. Fans shall be AMCA Certified for both Air and Sound Performance. Only AMCA Certified fans are acceptable.

B. Basis of design: Fantech FG.

C. Manufacturer:

1. Greenheck TCB
2. Cook TCN
3. Twin City TCLB
4. Car-Mon
D. Performance: Fan performance shall be based on tests conducted in accordance with AMCA Standard Test Code for Air Moving Devices. Fans shall be non-overloading and shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics shall be truly non-overloading and shall reach a peak in the normal selection area. Fan manufacturer shall provide sound power ratings in the eight octave bands that shall be based on AMCA Standard 300, test set up No. 1. Sound power ratings shall be in decibels referenced 10-12 watts.

E. Wheels: All wheels shall have backwardly inclined blades for maximum efficiency. The blades shall be continuously welded to the backplate and wheel cone. Wheel diameters shall be in accordance with the standard sizes adopted by AMCA for tubular centrifugal fans.

F. Housings: Housings shall be heavy gauge steel, structurally reinforced and suitable braced to prevent vibration and pulsation. Housings shall be arc welded throughout. Lifting lugs shall be welded to the housing to facilitate handling of the fans. Straightening vanes shall be standard construction to assure maximum efficiency and lowest noise levels.

G. Shaft and Bearings: The first critical shaft speed shall be at least 142% of the fan’s maximum operating speed. This critical speed will refer to the top of the speed range for the fan’s AMCA class. Bearings shall be designed for heavy duty service with a minimum L50 life of 250,000 hours. Bearings ratings shall be based on the fan’s maximum cataloged operating speed. Bearings shall be heavy duty, either single row ball or double row spherical roller type in a one-piece cast iron housing, or a double row spherical roller type in a split cast iron pillowblock.

H. Balancing: A factory dynamic balance shall be made on all fans after their assembly. An IRD or PMC analyzer shall be used to measure velocity, and the final reading shall not exceed 0.1 inches per second. The exact level of vibration shall be recorded on the fan as proof of the final dynamic balance at the factory.

I. Accessories: Accessories shall include belt guard, weather cover, bolted access door, quick open access door, discharge flange, inlet flange, companion flange, inlet screen, shaft seal, discharge cap, curb cap, spark resistant construction, and extended grease fittings.

2.6 CABINET FANS

A. General: Provide the cabinet fans where shown on the drawings; size and capacity as indicated. Motor horsepowers and outlet velocities shall not be exceeded. All fans shall be AMCA Certified for both Air and Sound Performance. Only AMCA Certified fans are acceptable.

B. Basis of design: Greenheck BDF

C. Manufacturer:

1. Greenheck BDF
2. Cook DB
3. Twin City DBS
4. Car-Mon
D. Type: Units shall be specially designed for quiet operation, self-contained in sheet steel housing, and shall be manufacturer's standard cataloged equipment with ratings and details available in printed form. Entire assembly shall comply with dimensional limitations on the drawings.

E. Fans: Double-inlet, backward inclined wheel, permanently sealed ball bearings.

F. Casing: Heavy gauge galvanized steel, factory enamel finished, casing reinforced with structural steel angles or channels, inlet and outlet openings flanged for connection to ductwork. Interior of casing shall be lined with noncombustible, mat faced, fiberglass acoustical sound lining, not lighter than 1" thickness. For cabinet fans with motor and drive located within the cabinet, provide suitable tight-closing hinged doors for access to drive and motor.

G. Motors and Drives: Motors shall be high-efficiency type. Drives shall be V-belt type as specified in "Fan Drives" elsewhere in this section. Mount motors on slide rails or similar arrangement for tightening the drive.

H. Filters: Provide two-inch thick disposable air filters at inlet of each cabinet fan, flat or v-bank, not to exceed 250 FPM.

2.7 CEILING-TYPE EXHAUST FANS

A. Provide the ceiling type exhaust fans at locations shown, capacity as indicated. Fans shall have acoustically insulated housings and bear AMCA Certified Ratings Seal and the UL label. Manufacturer shall submit vibration amplitudes and magnetic motor hum levels in decibels.

B. Basis of design: Greenheck SP

C. Manufacturer:

   1. Greenheck SP
   2. Cook Gemini
   3. Pennberry Zephyr
   4. Car-Mon

D. Fans shall have acoustically insulated housings and bear AMCA Certified Ratings Seal and the UL label. Manufacturer shall submit vibration amplitudes and magnetic motor hum levels in decibels.

E. Fans shall include integral backdraft damper, totally chatterproof with no metal-to-metal contact. Fan shall have centrifugal wheel. Provide terminal box on housing for electrical connection. Entire fan, motor and wheel assembly shall be easily removable without disturbing the housing.

F. Motor speeds shall not exceed 1100 rpm and all fan motors shall be suitably grounded and mounted on rubber-in-shear vibration isolators. Each fan shall be provided with a variable speed controller mounted at fan to maintain design CFM flow.

G. Fans shall be provided without grilles.
H. Provide wall exhaust louver or roof cap as shown, same manufacturer as fan.

I. In-Line Type Ceiling Fans: Provide with in-line type cabinet, location and capacity as indicated, lined housing, centrifugal direct-driven fan wheel. Motors shall not exceed 1100 rpm and shall be mounted on vibration isolators.

PART 3 - EXECUTION

3.1 EXAMINATION
A. Examine fans before installation. Reject fans that are wet, moisture damaged, or mold damaged.

3.2 INSTALLATION-FANS
A. General: The installation of the fans shall conform to local codes and ordinances, NFPA 90A, and SMACNA. Mounting and supporting of all equipment including accessories and appurtenances shall be provided, including but not limited to structural supports, hangers, vibration isolators, stands, clamps, and brackets.

B. Installation of Equipment: Installation shall conform to equipment manufacturer's recommendations, unless otherwise indicated. Equipment shall be installed, leveled and located so that working clearance is available under overhead lines and so that working space is available for all necessary servicing such as shaft removal, replacing or adjusting drives and motors, lubrication, and access to automatic controls.

3.3 ELECTRICAL WORK
A. General: Electric motor-driven equipment specified in this section shall be provided complete with motors and controls. Electric equipment and wiring shall comply with requirements of NFPA 70 and Division 26, "Electrical Work".

B. Starters: Motor starters and disconnects, unless otherwise specified or indicated shall be furnished and installed by Division 26 Contractor.

3.4 IDENTIFICATION
A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section 260553, "Identification for Electrical Systems."

3.5 COMMISSIONING
A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.
C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233400
SECTION 233700 - AIR INLETS AND OUTLETS

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 ceiling- and wall-mounted diffusers, registers, and grilles.

B. Related Sections include the following:

1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each 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.

1.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 2 - PRODUCTS

2.1 DIFFUSERS

A. General: Diffusers shall be sizes and mounting types shown on drawings and as scheduled. All diffusers shall be provided with earthquake tabs where required by code. Whether required by code or not, all diffusers shall be provided with earthquake tabs if the weight of the assembly (including all accessories and the plenum above) is more than fifteen (15) pounds unless the assembly is rigidly attached to, and can be fully supported from, a fully-supported sheet-metal duct or plenum.
B. Square Face Modular Core Adjustable Diffusers:

1. 1, 2, 3, or 4-way adjustable discharge pattern, steel construction, square or rectangular neck.
2. Back pan shall be one-piece stamped heavy gauge steel. Diffuser neck shall have 1-inch minimum depth to facilitate duct connection.
3. Diffuser core shall consist of fixed louver directional modules, which can be easily repositioned without tools in the field for 1, 2, 3, or 4-way discharge. Each module shall be easily removable to adjust the dampers in neck of the diffuser.

C. Titus MCD has lowest NC levels. Catalog data for the other manufacturers indicates a much higher NC level. Consider using a lower neck velocity when selecting the diffuser and indicate on the drawings.


2.2 GRILLES AND REGISTERS

A. General: Grilles and registers shall be sizes and mounting types shown on drawings and as scheduled.

B. Steel Supply Grilles:

1. Grilles shall be double deflection type unless indicated otherwise on the drawings. Exposed deflection blades shall be horizontal when viewed from the room (typically, the first dimension indicated is the horizontal dimension).
2. Grilles shall be steel construction with a 1-1/4" wide border on all sides, having a minimum thickness of 20-gauge. Screw holes shall be countersunk. Corners shall be welded with full penetration resistance welds with a reinforcing steel patch for extra strength.
3. Deflection blades shall be constructed of heavy-duty aluminum spaced on 3/4" centers. Blades shall extend completely through the side frame on each side to provide stability throughout the complete CFM operating range of the grille. Blades shall be individually adjustable without loosening or rattling, and shall be held in place with tension wire.
4. Manufacturers:

a. Double deflection, blades parallel to long dimension:
   1) Titus Model 300RL
   2) Price
   3) Nailor

b. Double deflection, blades parallel to short dimension:
   1) Titus Model 300RS
   2) Price
   3) Nailor

c. Single deflection, blades parallel to long dimension:
1) Titus Model 301RL
2) Price
3) Nailor

d. Single deflection, blades parallel to short dimension:

1) Titus Model 301RS
2) Price
3) Nailor

C. Wall-Mounted Steel Return and Exhaust Grilles:

1. Grilles shall have fixed deflection blades, which shall be horizontal when viewed from the room (typically, the first dimension indicated is the horizontal dimension).
2. Grilles shall be steel construction with a 1-1/4" wide border on all sides, having a minimum thickness of 20-gauge. Screw holes shall be countersunk. Corners shall be welded with full penetration resistance welds with a reinforcing steel patch for extra strength.
3. Blades shall have a formed curvature, laboratory tested and certified for performance. Blades shall be 20-gauge minimum construction. Fixed deflection angle shall be 35°.
4. Where indicated, integral opposed blade dampers shall be provided, constructed of heavy gauge steel. Damper shall be operable from the face of the grille.
5. Borders of grilles shall be suitable for installation surface and materials. Border type shall be surface mount or otherwise as indicated or required for the associated surface. Verify border requirements.
6. Manufacturers:

a. 35° Deflection, 3/4" Spacing, Blades Parallel to Long Dimension:

1) Titus Model 350RL
2) Anemostat
3) Carnes
4) Krueger
5) Price
6) Metalaire.
7) Nailor

b. 35° Deflection, 3/4" Spacing, Blades Parallel to Short Dimension:

1) Titus Model 350RS
2) Anemostat
3) Carnes
4) Krueger
5) Price
6) Metalaire.
7) Nailor

D. Ceiling-mounted Steel Return and Exhaust Grilles:

1. Except as noted below, grilles shall be the same as specified for wall-mounted grilles.
2. Grilles in lay-in ceilings shall not have screw holes in the border.
3. Grilles shall have fixed deflection blades, which shall be perpendicular to the line of sight when viewed from the center of the room.

4. Borders of grilles shall be suitable for installation surface and materials. Border type shall be surface mount, snap-in, lay-in, spline, or channel frame type as indicated or required for the associated surface. Verify border requirements.

E. Registers:

1. Provide where registers or integral dampers are indicated on the drawings. Same as specified for grilles, except with heavy gauge aluminum opposed blade damper, operable from face of the register.

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 EQUIPMENT AND MATERIALS PROTECTION: Adequately protect equipment and materials against physical damage. Place equipment and materials in first class operating condition, or return to source of supply for repair or replacement, as determined by A/E. Protect all equipment and materials from moisture at all times. Protect during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

3.3 INSTALLATION

A. There is also a standard detail available for the Diffuser Connection below.

B. Diffuser Connection: Provide a minimum of 12” of straight (vertical) duct above ceiling diffusers or furnish an engineer prior approved plenum above diffusers.

C. Install diffusers, registers, and grilles level and plumb in accordance with the details and notes indicated and the recommendations and printed instructions of the manufacturer for each item.

D. 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 practicable. 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.

E. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
F. Exhaust Grilles in Rooms with Showers: As specified for exhaust grilles in general, except all aluminum construction.

G. Frames and Borders:
   1. Diffusers and grilles shall have border or margins for tight fit to ceilings for optimum ceiling appearance, designed to cover ceiling openings and minimize dirt development on ceiling. All diffusers and grilles shall be provided with duct rings secured to diffuser or grille outer shell with concealed fasteners.
   2. Square Diffusers and Grilles for Exposed "Tee" Grid Ceilings: Square diffusers and grilles that fit well within the framing grid shall be flanged. Where dimension corresponds to the grid dimension, diffuser or grille shall be the same pattern as specified above except margins shall be 5/8" wide with outside dimensions for "lay-in" installation in the standard tee spacing required by the architectural drawings.

H. Ceiling Grille Orientation: Return and exhaust grilles and registers shall be installed in ceilings such that the blade angle blocks line-of-sight into the duct from the center of the room. If the best orientation still allows the ductwork interior to be seen through the grille from any point in the room that is more than 3 feet from a wall, the visible portion of the interior shall be painted with flat-black paint.

I. Structural Supports: When very large diffusers are installed, sufficient structural support shall be provided to prevent sagging or distortion of the unit. Provide seismic restraints to prevent diffuser from being dislodged from the ceiling.

J. Where diffuser and ceiling grille assemblies that weigh more than 15 pounds (and less when required by code), they shall be fully supported independent of a lay-in ceiling grid.

3.4 ADJUSTING
   A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing. Set throw direction at all linear diffusers and modular core diffusers. In general, air shall be directed away from adjacent walls, unless indicated otherwise on the drawings. Request engineer direction if proper arrangement is not readily apparent.

3.5 COMMISSIONING
   A. Notify the Commissioning Agent one week prior to startup of equipment.
   B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.
   C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 23 37 00
SECTION 234100 - PARTICULATE AIR FILTRATION

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 factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. HEPA: High-efficiency particulate air.

C. ULPA: Ultra low penetration air.

D. MERV: Minimum Efficiency Reporting Value

1.4 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.

C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.
1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. 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.

C. Comply with ARI 850.

D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 70 for installing electrical components.

F. Comply with NFPA 90A and NFPA 90B.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 EXTRA MATERIALS

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. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.

2. Provide one container of red oil for inclined manometer filter gage.

PART 2 - PRODUCTS

2.1 AIR FILTERS

A. Pleated Panel Air Filters (Pre-Filters):

1. Manufacturers:
   a. Farr Company Type 30/30
   b. Flanders Airpure
   c. American Air Filter.

2. General: Provide the air filters, complete with filter cartridges and holding frames. Filter banks shall be field erected, size and arrangement as shown on the drawings. Each filter shall be provided with an identification plate, visibly mounted after construction showing serial number, model number and all other data necessary for ordering renewable media.
3. Filter Media: Non-woven cotton fabric type, reinforced by a woven scrim backing. Synthetic media material (polyester) is not acceptable.

4. Media Support: Media support shall consist of a welded wire grid, effective open area of not less than 96%. Grid shall be bonded to filter media for rigidity.

5. Enclosing Frame: Rigid, heavy-duty beverage board with diagonal support members bonded to the air entering and an exit side of each pleat, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack so as to eliminate air bypass.

6. Ratings:
   a. Filter shall be rated MERV 8 per ASHRAE 52.2.
   b. The filter media shall have an average efficiency of 25% to 30% on ASHRAE Test Standard 52.1-92.
   c. Media shall have an average synthetic dust arrestance of 90-93% in accordance with ASHRAE Test Standard 52.1-92.
   d. Filters shall be UL Class 2.

7. Effective Filter Media:
   a. Drawings should indicate thickness at each unit if more than one thickness is specified
   b. 4" Thick: The effective filter media for the 4" thick filters shall be not less than 6.75 sq. ft. of media per 1.0 sq. ft. of filter face area and shall contain 9 pleats per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed 0.18 in. w.g.
   c. 2" Thick: The effective filter media for the 2" thick filters shall be not less than 3.3 sq. ft. of media per 1.0 sq. ft. of filter face area and shall contain not less than 10 pleats per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed 0.28 in. w.g.
   d. 1" Thick: The effective filter media for the 1" thick filters shall be not less than 2.5 sq. ft. of media per 1.0 sq. ft. of filter face area and shall contain not less than 16 pleats per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed 0.36 in. w.g.
   e. Some clients require that we refer to the last filters in an AHU as the intermediate filters and refer to filters (if any) at the diffusers as the final filters. Check with the client and be consistent in your terminology.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.
E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

G. Electrical wiring and connections are specified in Division 26 Sections.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Each filter shall be identified in accordance with the identification system indicated on the schedule or drawings with labels complying with Division 23 Section “Identification for HVAC Piping and Equipment”. Identification on unit shall be readable from the floor through the primary service access opening.

3.2 EQUIPMENT AND MATERIALS PROTECTION: Adequately protect equipment and materials against physical damage. Place equipment and materials in first class operating condition, or return to source of supply for repair or replacement, as determined by A/E. Protect all equipment and materials from moisture at all times. Protect during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components, filter and filter-frame installation, and electrical wiring, and to assist in field testing. Report results in writing in the O&M Manual.

B. Operate automatic roll filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating. Correct malfunctioning units then retest to demonstrate compliance. Remove and replace units that cannot be corrected with new units and retest.

C. HEPA Filters:

1. Pressurize housing to a minimum of 3.0 in. w.g. (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.

2. OR Pressurize housing to a minimum of 3.0 in. w.g. (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510 pressure-decay method.

3.4 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

B. Utilize temporary high-efficiency filters during testing, balancing and commissioning to keep all systems clean. Provide temporary obstructions as needed to simulate dirty filter conditions.
A complete set of new filters shall be provided no more than 4 days prior to owner's occupancy of building.

3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 234100
SECTION 237000 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

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.

B. Section 233100 – HVAC Ducts and Casings.

C. Section 230900 – Instrumentation and Control for HVAC.

1.2 SUMMARY

A. Section Includes:


1.3 SYSTEM DESCRIPTION

A. Energy recovery mini-ventilators shall be designed for use in indoor applications requiring up to 1000 CFM for ventilation. ERVs shall utilize a standard fixed-plate cross-flow construction. Units shall be constructed for floor or ceiling mounted.

1. The Energy Recovery Ventilator shall be rated in accordance with AHRI Standard 1060-2014 with ratings certified by AHRI.

2. ERVs shall be complete with low ambient kit for frost control, controller for economizer mode, and rotation sensor utilizing dry contact switch that closes upon failure.

1.4 PERFORMANCE REQUIREMENTS

A. Energy Transfer

1. The ERV shall be capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air.

B. Passive Frost Control

1. The ERV core shall perform without condensing or frosting under normal operating conditions (defined as outside temperatures above -10°F and inside relative humidity below 40%). Occasional more extreme conditions shall not affect the usual function, performance or durability of the core. No condensate drains will be allowed.
C. Continuous Ventilation
   1. Unit shall have the capacity to operate continuously without the need for bypass, recirculation, pre-heaters, or defrost cycles under normal operating conditions.

D. Positive Airstream Separation
   1. Water vapor transfer shall be through molecular transport by hydrosopic resin and shall not be accomplished by “porous plate” mechanisms. Exhaust and fresh airstreams shall travel at all times in separate passages, and airstreams shall not mix. No metal separators or metal core material shall be acceptable.

E. Laminar Flow
   1. Airflow through the ERV core shall be laminar over the products entire operating airflow range, avoiding deposition of particulates on the interior of the energy exchange plate material.

1.5 REFERENCES
   A. AMCA 511 – Certified Ratings Program for Air Control Devices.
   D. Underwriter’s laboratory (UL) 1812 - Standard for Ducted Heat Recovery Ventilators.
   E. Underwriter’s laboratory (UL) 1995 - Heating and Cooling Equipment

1.6 SUBMITTALS
   A. Product Data: Submit for each air-handling unit indicated.
      1. Unit dimensions and weight.
      2. Cabinet material, metal thickness, finishes, insulation, and accessories.
      3. Fans:
         a. Certified fan-performance curves with system operating conditions indicated.
         b. Certified fan-sound power ratings.
         c. Fan construction and accessories.
         d. Motor ratings, electrical characteristics, and motor accessories.
      4. Certified coil-performance ratings with system operating conditions indicated.
      5. Dampers, including housings, linkages, and operators.
      6. Filters with performance characteristics.
B. LEED Submittals:

2. Product Data for Credit EA 5: For continuous metering equipment for outdoor airflow and energy consumption.

C. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source Quality-Control Reports.

E. Field Quality-Control Reports.

F. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.7 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. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

C. Comply with NFPA 70.

D. The energy recovery ventilator shall be Certified by the Home Ventilating Institute (HVI) under CSA 439*. Both a heating and a cooling test must be run to demonstrate year-round energy recovery.

E. Manufacturer shall be able to provide evidence of independent testing of the core by Underwriters Laboratory (UL), verifying a maximum flame spread index (FSI) of 25 and a maximum smoke developed index (SDI) of 50 thereby meeting NFPA 90A and NFPA 90B requirements for materials in a compartment handling air intended for circulation through a duct system. The method of test shall be UL Standard 723.

F. Unit shall be Listed under UL 1812 Standard for Ducted Air to Air Heat Exchangers. The unit must pass commercial flammability requirements and shall not be labeled “For Residential Use Only”.

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The ERV core shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of ten years from the date of purchase. The balance-of-unit shall be warranted to be free of manufacturing defects and to retain its functional characteristics, under circumstances of normal use, for a period of five years from the date of purchase.

1.8 COORDINATION
   A. Coordinate sizes and locations of concrete bases with actual equipment provided.
   B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.9 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. Filters: One set for each air-handling unit.
      2. Fan Belts: One set for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Basis-of-Design: Renewaire EV.
   B. Manufacturers:
      1. Renewaire
      2. Greenheck
      3. Ruskin

2.2 UNIT CONSTRUCTION
   A. The energy recovery component shall be of fixed-plate cross-flow construction, with no moving parts.
   B. No condensate drain pans or drains shall be allowed and unit shall be capable of operating in both winter and summer conditions without generating condensate.
   C. The unit case shall be constructed of 24-gauge steel, with lapped corners and zinc-plated screw fasteners. The case shall be finished with textured, powder coat paint.
   D. Access doors shall provide easy access to blowers, ERV cores, and filters. Doors shall have an airtight compression seal using closed cell foam gaskets.
E. Case walls and doors shall be fully insulated with 1 inch, expanded polystyrene foam insulation faced with a cleanable foil face on all exposed surfaces.

F. The ERV cores shall be protected by a MERV-8 rated, spun polyester, disposable filter in both airstreams.

G. The unit shall have a line-cord power connection and be supplied with an internal 24 VAC transformer and relay.

H. Standby power draw shall not exceed 1 Watt for the unit along with an optional automatic control.

I. VRF interlock controls.

2.3 SOURCE QUALITY CONTROL

A. Factory Tests: Manufacturer shall provide run test after unit is ready for shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Inspect areas to receive ERVs. Notify the Engineer of conditions that would adversely affect the installation or subsequent utilization of the units. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install ERVs per manufacturer’s instructions.

B. Unit Location

1. Locate, orient, and connect ductwork per AMCA, ASHRAE, and SMACNA guidelines. Provide service clearances as indicated on the plans. Locate units distant from sound critical occupancies.

2. Use integral mounting flange and hanging bar system to mount the unit per manufacturer's installation manuals to a structurally suitable surface. The units may be mounted in any orientation.

C. Vibration Isolation
1. If vibration isolation is required, utilize factory supplied Neoprene pads as necessary to help provide vibration isolation for the unit.
2. Provide flexible duct connections at unit duct flanges.

D. Duct Design

1. All ductwork shall be designed, constructed, supported and sealed in accordance with SMACNA HVAC Duct Construction Standards and pressure classifications.
2. At a minimum all duct runs to the outdoors shall be thermally insulated at levels appropriate to the local climate. A continuous vapor barrier shall also be provided on warm surface of the insulation.

E. Sound Control

1. To control sound radiated from the unit:
   a. Provide acoustic treatment in mechanical room walls and ceilings.
2. To control sound associated with the two blower outlets:
   a. Utilize insulated, flexible duct.
   b. In sound critical applications provide increased duct sizing and consider the use of sound attenuators.

F. Test and Balancing

1. Test and Balancing may not begin until 100% of the installation is complete and fully functional.
2. Follow National Environmental Balancing Bureau (NEBB) air test and balance procedures specific to energy recovery devices. Provide balancing reports to owner's representatives.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23, Section 232113, "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
F. Steam and Condensate Piping: Comply with applicable requirements in Division 23, Section 232213, "Steam and Condensate Heating Piping." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

G. Refrigerant Piping: Comply with applicable requirements in Division 23, Section 232300, "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

H. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23, Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

3.5 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. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.
B. Comply with requirements in Division 23, Section 230593, "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After startup service, clean air-handling units internally on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.
B. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, clean filter housings and install new, clean filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

3.9 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.
B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.
C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 237000
SECTION 238136 - VARIABLE REFRIGERANT FLOW CONDENSING UNIT

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.

B. Requirements under this section include required work that is common to multiple sections in Division 22 and 23 and shall be complied with by all suppliers and subcontractors.

C. Related Sections include but are not limited to the following:
   1. Division 23 Section 232300, “Refrigerant Piping”
   2. Division 23 Section 238239, “Variable refrigerant flow Terminal Units”

1.2 SYSTEM DESCRIPTION

A. This Section includes the following:
   1. VRF System
   2. Condensing Unit
   3. Branch Selector Box
   4. Refrigerant Piping

1.3 DEFINITIONS

A. The following are industry abbreviations:
   1. VRF: Variable refrigerant flow
   2. OEM: Original Equipment Manufacturer

1.4 SUBMITTALS

A. Provide submittals per Division 01, Section 013300, “Submittal Procedures.”

B. OEM factory training certifications proof prior to starting the project for all personnel installing the VRF system.

C. Product Data: Submit product data for each type of product indicated herein. Include and indicate construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

D. Field quality-control test reports.
E. List of certified local service contractors.

F. Shop drawings.

G. Operation and Maintenance Data: For each type of product indicated, include operation manual, replacement part list, and maintenance manuals.

1.5 PROJECT CONDITIONS

A. Do not install products or materials that are wet, moisture damaged, or mold damaged.

B. Field Measurements: Verify actual dimensions of site conditions by field measurements before fabrication.

1.6 COORDINATION

A. Coordinate size, location, routing, penetrations, supports, clearances and access for materials and products with all trades prior to installation.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Acceptable delivered materials and products must be devoid of scratches, dings, or damages. Materials and products must be kept and stored out of the weather and be sealed from accumulation of dust, dirt, and moisture. Materials and products shall only be removed from protected storage and packaging for installation.

B. Store equipment per manufacturer’s recommendations.

1.8 QUALITY ASSURANCE

A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.

B. Refrigerant pipe routing shall be in accordance with ASHRAE Standard 15-2016.

C. All wiring shall be in accordance with the National Electric Code (NEC).

D. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

E. Mechanical equipment for wind-born debris regions shall be designed in accordance with ASCE 7-2010 and installed to resist the wind pressures on the equipment and the supports.

F. The condensing unit will be factory charged with R-410A.

G. The system must be installed by a OEM factory trained contractor/dealer. The bidders shall be required to submit training certification proof prior to starting the project. The mechanical
contractor’s installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements

H. The system must be installed by certified OEM factory trained contractors. Certified contractors shall not supervise uncertified personnel. All personnel must be certified.

I. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."


K. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

L. Contractor must have refrigerant piping license.

M. The approved product shall have a qualified manufacturer certified service contractor within a 50-mile radius of the project.

N. Manufacturer’s representative shall conduct a minimum of three quality assurance meetings as follows; pre-installation, 50% installation, and final commissioning/start-up.

O. The system shall be inspected and signed off by a qualified regional factory representative (other than the installing contractor).

P. Owners representative may select 3 pipe joints for removal and inspection.

1.9 PROJECT SPECIFIC REQUIREMENTS

A. The variable capacity air conditioning system shall be a OEM variable refrigerant flow Series (heat and cool model) split system as specified. The system shall consist of multiple evaporators, branch selector boxes, joints and headers, a three-pipe refrigeration distribution system using PID control and OEM VRF condenser unit. The condenser shall be a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant. The condensing unit may connect an indoor evaporator capacity up to 200% of the condensing unit capacity. All zones are each capable of operating separately with individual temperature control. A dedicated hot gas pipe shall be required to ensure optimum heating operation performance. Two-pipe, heat recovery systems utilizing a lower temperature mixed liquid/gas refrigerant to perform heat recovery are not acceptable due to reduced heating capabilities.

B. The OEM condensing unit shall be interconnected to indoor unit models and shall range in capacity from 7,500 Btu/h to 96,000 Btu/h in accordance with OEM’s engineering data book detailing each available indoor unit. The indoor units shall be connected to the condensing unit utilizing OEM’s specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable.

C. Operation of the system shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with each branch of the cool/heat selector box. Each indoor unit or group of indoor units shall be able to provide set temperature
independently via a local remote controller, an Intelligent Controller, an Intelligent Manager or a BMS interface.

D. Branch selector boxes shall be located as shown on the drawing. The branch selector boxes shall have the capacity to control up to 216 MBH (cooling) downstream of the branch selector box. Each branch of the branch selector box shall consist of five electronic expansion valves, refrigerant control piping and electronics to facilitate communications between the box and main processor and between the box and indoor units. The branch selector box shall control the operational mode of the subordinate indoor units. The use of five EEV’s ensures continuous heating during defrost, no heating impact during changeover and reduced sound levels. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.

1.10 WARRANTY

A. Standard Limited Warranty - The warranty period is limited in duration to one (1) year from the date of substantial completion. Issues that arise and are addressed during the warranty period, but are not resolved before the end of the limited warranty shall be covered under the warranty.

B. Extended Warranty - Compressors shall be for a seven (7) year period from the date of substantial completion. Issues that arise and are addressed during the warranty period, but are not resolved before the end of the extended warranty shall be covered under the warranty.

PART 2 – PRODUCTS

2.1 DESIGN BASIS

A. The HVAC equipment basis of design is OEM AC. All bidders shall furnish the minimum system standards as defined by the base bid model numbers, model families or as otherwise specified herein. The contractor shall be responsible for all specified items and intents of this document without further compensation.

2.2 VRF SYSTEM

A. Voltage Platform – Condensing units shall be available with a 208~230V/1-phase/60Hz power supply.

B. Defrost Heating – Each system shall maintain continuous heating during defrost operation. Reverse cycle (cooling mode) defrost operation shall not be permitted due to the potential reduction in space temperature.

C. Oil Return Heating – Each system shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.

D. Independent Control – Each indoor unit shall use a dedicated electronic expansion valve for independent control.
E. VFD Inverter Control – Each condensing unit shall use a high efficiency, variable speed “inverter” compressor coupled with inverter fan motors for superior part load performance.

F. Compressor capacity shall be modulated automatically to maintain constant suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads.

G. Indoor units shall use PID to control superheat to deliver a comfortable room temperature condition and optimize efficiency.

H. Flexible Design –
   1. Systems shall be capable of 49ft between indoor units.
   2. Condensing units shall be supported with a fan motor ESP up to 0.80”. WG as standard to allow connection of discharge ductwork and to prevent discharge air short circuiting.

I. Simple Wiring – Systems shall use 16/18 AWG, 2 wire, multi-stranded, non-shielded and non-polarized daisy chain control wiring.

J. Energy Efficiency – System shall have equivalent or better performance than local energy code.

K. Outside Air – Systems shall provide outside air capability.

L. Space Saving – Each system shall have a condensing unit module footprint as small as 3’ 5/8” x 2’ 6/18” (7.66sq ft).

M. Advanced Diagnostics – Systems shall include a self diagnostic, auto-check function to detect a malfunction and display the type and location.

N. Each condensing unit shall incorporate contacts for electrical demand shedding.

O. Advanced Controls – Each system shall have at least one remote controller capable of controlling up to 16 indoor units.

P. Each system shall be capable of integrating with open protocol BACnet and LonWorks building management systems.

Q. Low Sound Levels – Each system shall use indoor and condensing units with quiet operation as low as 27 dB(A).

2.3 CONDENSING UNIT

A. General: The condensing unit is designed specifically for use with VRF series components.
   1. The condensing unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of OEM scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
   2. High/low pressure gas line, liquid and suction lines must be individually insulated between the condensing and indoor units.
3. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
4. The connection ratio of indoor units to condensing unit shall be permitted up to 200%.
5. Each condensing system shall be able to support the connection of up to 56 indoor units dependant on the model of the condensing unit.
6. The sound pressure level standard shall be that value as listed in the OEM engineering manual for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time.
7. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
8. The unit shall incorporate an auto-charging feature.
9. The condensing unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
10. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
11. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
12. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.
13. The condensing unit shall be capable of heating operation at 0°F dry bulb ambient temperature without additional low ambient controls or an auxiliary heat source.
14. The system shall continue to provide heat to the indoor units in heating operation while in the defrost mode. Reverse cycle (cooling mode) defrost during heating operation shall not be permitted due to the potential reduction in space temperature.

B. Unit Cabinet:

1. The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

C. Fan:

1. The condensing unit shall consist of one or more propeller type, direct-drive 350 or 750 W fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.30 in. WG. A field setting switch to a maximum 0.80 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.
3. The fan shall be a vertical discharge configuration with a nominal airflow maximum range of 6,700 CFM to 20,650 CFM dependent on model specified.
4. Nominal sound pressure levels shall not exceed 60 dB(A).
5. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
6. The fan motor shall be provided with a fan guard to prevent contact with moving parts.
7. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature. Operation sound level shall be selectable from 3 steps 27,31 & 35 dB(A)

D. Condenser Coil:

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins are to be covered with an anti-corrosion acrylic resin and hydrophilic film type E1.
5. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.

E. Compressor:

1. The OEM inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.
2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll “G2-type” with a maximum speed of 7,980 rpm.
3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
4. The capacity control range shall be as low as 4% to 100%.
5. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
6. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
7. Oil separators shall be standard with the equipment together with an intelligent oil management system.
8. The compressor shall be spring mounted to avoid the transmission of vibration.
9. Units sized 6-12 tons shall contain a minimum of 2 compressors. 14-ton units shall contain a minimum of 3 compressors. 16-20 ton units shall contain a minimum of 4 compressors. 22-24 ton units shall contain a minimum of 5 compressors. 26-28 ton units shall contain a minimum of 6 compressors. In the event of compressor failure the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.
10. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of
each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours.

F. Operating Range:

1. The operating range in cooling will be 23°F DB ~ 122°F DB.
2. The operating range in heating will be 0°F DB – 77°F DB / -4°F WB – 60°F WB. Simultaneous cooling/heating operating range will be (-4°F) 23°F WB ~ 60°F WB.
3. Cooling mode indoor room temperature range will be 57°F-77°F WB. Heating mode indoor room temperature range will be 59°F-80°F DB.

G. Electrical:

1. The power supply to the condensing unit shall be 208~230V/1-phase/60Hz +/- 10%.
2. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded, stranded 2 conductor cable.
3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one condensing unit with one 2-cable wire, thus simplifying the wiring installation.

2.4 BRANCH SELECTOR BOX

A. General: The branch selector boxes are designed specifically for use with VRF series heat recovery system components.

1. These selector boxes shall be factory assembled, wired, and piped.
2. These branch controllers must be run tested at the factory.
3. These selector boxes must be mounted indoors.
4. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling electronic expansion valve.

B. Unit Cabinet:

1. These units shall have a galvanized steel plate casing.
2. Each cabinet shall house 5 electronic expansion valves for refrigerant control per branch.
3. The cabinet shall contain one subcooling heat exchanger per branch.
4. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

C. Dimensions:

1. Each unit shall be no larger than 8-3/16” x 15-5/16” x 12-7/8”.

D. Refrigerant Valves:

1. The unit shall be furnished with 5 electronic expansion valves per branch to control the direction of refrigerant flow. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.
2. The refrigerant connections must be of the braze type.
3. Each circuit shall have at least one branch selector box.
4. Multiple indoor units may be connected to a branch selector box with the use of a joint provided they are within the capacity range of the branch selector.

5. Solenoid Valves: Two way normally closed with two-piece brass body, full port, stainless steel plug, stainless steel spring, Teflon diaphragm and solder end connections. Provide replaceable coil assembly.


7. Thermostatic Expansion Valves: Brass body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

8. Charging Valves: Provide ¼” SAE brass male flare access ports with finger tight, quick seal caps. Provide 2-inch long copper extension sections.

9. Check valves: Spring loaded type with bronze body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

E. Condensate Removal:

1. The unit shall not require provisions for condensate removal.

F. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.

2. The unit shall be capable of operation within the limits of 187 volts to 253 volts.

3. The minimum circuit amps (MCA) shall be 0.1 and the maximum overcurrent protection amps (MOP) shall be 15.

4. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded 2 conductor cable.

2.5 REFRIGERANT PIPING

A. Piping selection and installation to comply with Division 23 Section 232300, “Refrigerant Piping”.

B. Piping from condensing unit to selector boxed shall be brazed and ASTM B88 type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR", with ANSI B16.22 wrought copper or forged brass solder-type fittings. Piping installation shall be in accordance with manufactures requirements.

C. The system shall be capable of refrigerant piping up to 540 actual feet or 620 equivalent feet from the condensing unit to the furthest indoor unit, a total combined liquid line length of 3,280 feet of piping between the condensing and indoor units with 295 feet maximum vertical difference, without any oil traps.

D. piping joints and headers shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance. T style joints shall not be acceptable as this will negatively impact proper refrigerant balance and flow for optimum system capacity and performance.

E. For systems using R-410A, provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 800 psig and a maximum working temperature of 225F.
PART 3 – EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. Installation to comply with Division 23 Section 232300, “Refrigerant Piping”.

B. The system must be installed by a OEM factory trained contractor/dealer.

C. System shall be installed with the strict standards provided by the manufacturer.

D. Install all piping parallel to building walls and ceilings and at heights that do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

E. Do not route piping through transformer vaults or above transformers, panel boards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

F. Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

G. Metal pipe hangers must not come in direct contact with the refrigerant piping. Utilize hangers that support the piping on the outside of the insulation, or hangers that incorporate a non-metallic inserts or non-metallic pipe hangers. Do not allow copper refrigeration piping to come in direct contract with dis-similar metals.

H. All joints must be brazed and have a melting point greater than 1,125 degrees F. Filler impurities shall not exceed 0.15%. Tubing to be new and delivered to the job site with the original mill end caps in place. Purge all lines with nitrogen during brazing. Provide manual shut-off and check valves as required.

3.2 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain VRF units.

END OF SECTION 238136
SECTION 238220 - VARIABLE REFRIGERANT VOLUME TERMINAL 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.
   B. Requirements under this section include required work that is common to multiple sections in
      Division 22 and 23, and shall be complied with by all suppliers and subcontractors.
   C. Related Sections include but are not limited to the following:
      1. Division 23 Section 238136, “Variable Refrigerant Condensers”

1.2 SYSTEM DESCRIPTION
   A. This Section includes the following:
      1. Concealed Ceiling Ducted Unit

1.3 DEFINITIONS
   A. The following are industry abbreviations:
      1. VRF: Variable refrigerant flow
      2. OEM: Original Equipment Manufacturer

1.4 SUBMITTALS
   A. Provide submittals per Division 01, Section 013300, “Submittal Procedures.”
   B. OEM factory training certifications proof prior to starting the project for all personnel installing
      the VRF system.
   C. Product Data: Submit product data for each type of product indicated herein. Include and
      indicate construction details, material descriptions, dimensions of individual components and
      profiles, and finishes. Include rated capacities, operating characteristics, electrical
      characteristics, and furnished specialties and accessories.
   D. List of certified local service contractors.
   E. Shop drawings
   F. Field quality-control test reports.
G. Operation and Maintenance Data: For each type of product indicated, include operation manual, replacement part list, and maintenance manuals.

1.5 PROJECT CONDITIONS
A. Do not install products or materials that are wet, moisture damaged, or mold damaged.
B. Field Measurements: Verify actual dimensions of site conditions by field measurements before fabrication.

1.6 COORDINATION
A. Coordinate size, location, routing, penetrations, supports, clearances and access for materials and products with all trades prior to installation.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Acceptable delivered materials and products must be devoid of scratches, dings, or damages. Materials and products must be kept and stored out of the weather and be sealed from accumulation of dust, dirt, and moisture. Materials and products shall only be removed from protected storage and packaging for installation.
B. Store equipment per manufacturer’s recommendations.

1.8 QUALITY ASSURANCE
A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995/CAN/CSA-C22.2 No. 236-05 (R2009) – Heating and Cooling Equipment and bear the Listed Mark.
B. Refrigerant pipe routing shall be in accordance with ASHRAE Standard 15-2016.
C. All wiring shall be in accordance with the National Electric Code (NEC)/Canadian Electrical Code (CEC).
D. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.
E. The outdoor unit will be factory charged with R-410A.
F. The system must be installed by a OEM factory trained contractor/dealer. The bidders shall be required to submit training certification proof prior to starting the project. The mechanical contractor’s installation price shall be based on the systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements
G. The system must be installed by certified OEM factory trained contractors. Certified contractors shall not supervise uncertified personnel. All personnel must be certified.
H. The system shall be inspected and signed off by a qualified regional factory representative (other than the installing contractor).

I. The approved product shall have a qualified manufacturer certified service contractor within a 50-mile radius of the project.

J. Manufacturer’s representative shall conduct a minimum of three quality assurance meetings as follows; pre-installation, 50% installation, and final commissioning/start-up.

1.9 WARRANTY

A. Standard Limited Warranty - The warranty period is limited in duration to one (1) year from the date of substantial completion. Issues that arise and are addressed during the warranty period, but are not resolved before the end of the limited warranty shall be covered under the warranty.

B. Extended Warranty - Compressors shall be for a seven (7) year period from the date of substantial completion. Issues that arise and are addressed during the warranty period, but are not resolved before the end of the extended warranty shall be covered under the warranty.

PART 2 – PRODUCTS

2.1 DESIGN BASIS

A. The HVAC equipment basis of design is OEM AC. All bidders shall furnish the minimum system standards as defined by the base bid model numbers, model families or as otherwise specified herein. The contractor shall be responsible for all specified items and intents of this document without further compensation.

2.2 CONCEALED CEILING DUCTED UNIT (MED. STATIC)

A. General: OEM indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation into the ceiling cavity. It is constructed of a galvanized steel casing. It shall be available in capacities from 48,000 Btu/h to 96,000 Btu/h. It shall be a horizontal discharge air with horizontal return air configuration. All models feature a low height cabinet making them applicable to ceiling pockets that tend to be shallow. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature when used with OEM remote control. The indoor units sound pressure shall be 48 dB(A) at low speed measured 5 feet below the ducted unit.

B. Indoor Unit:

1. The OEM indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall have an adjustable external static pressure switch.
2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be insulated from the outdoor unit.
4. The indoor units shall be equipped with a return air thermistor.
5. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
6. The voltage range will be 253 volts maximum and 187 volts minimum.

C. Unit Cabinet:
1. The cabinet shall be located into the ceiling and ducted to the supply and return openings.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

D. Fan:
1. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high and low fan speeds available.
2. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz, with a motor output of 0.51 HP.
3. The airflow rate shall be available in high and low settings.
4. The fan motor shall be thermally protected.
5. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.

E. Coil:
1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 3-row cross fin copper evaporator coil with 13 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1-5/16 inch outside diameter PVC.
5. A thermistor will be located on the liquid and gas line.

F. Electrical:
1. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

G. Control:
1. The unit shall have controls provided by OEM to perform input functions necessary to operate the system.
2. The unit shall be compatible with interfacing with a BMS system via optional LonWorks or BACnet gateways.
3. The unit shall be compatible with a OEM intelligent Touch advanced multi-zone controller or an intelligent Manager III customizable BMS. Consult with OEM prior to applying controls.

H. Accessories:

1. Remote “in-room” sensor kit
   a. The OEM wall mounted, hard wired remote sensor kit is recommended for ceiling-embedded type fan coils, which often result in a difference between set temperature and actual temperature. The sensor for detecting the temperature can be placed away from the indoor unit (branch wiring is included in the kit).

2. OEM Cold Climate/Snow Kit
   a. The OEM cold weather kit including unit stand, snow hood, base pan heater, compressor crank case heater.

I. Refrigerant Valves:

1. See Division 23 Section 238136, “Variable Refrigerant Condensers” 2.4 Branch Selector Box for valve requirements.

2.3 REFRIGERANT PIPING

A. Piping from selector box to the fan coil shall be Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

B. For systems using R-410A, provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 800 psig and a maximum working temperature of 225F.

PART 3 – EXECUTION

3.1 INSTALLATION REQUIREMENTS

A. The system must be installed by a OEM factory trained contractor/dealer.

B. System shall be installed with the strict standards provided by the manufacturer.

C. Piping from the selector box to the fan coil shall be cleanly run, orderly, and straight.

D. Install all piping parallel to building walls and ceilings and at heights that do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.
E. Do not route piping through transformer vaults or above transformers, panel boards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment.

F. Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

G. Metal pipe hangers must not come in direct contact with the refrigerant piping. Utilize hangers that support the piping on the outside of the insulation, or hangers that incorporate a non-metallic inserts or non-metallic pipe hangers. Do not allow copper refrigeration piping to come in direct contract with dis-similar metals.

3.2 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain VRF units.

END OF SECTION 238220
SECTION 238239 - UNIT 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. Cabinet unit heaters with centrifugal fans and electric-resistance heating coils.
   2. Propeller unit heaters with electric-resistance heating coils.
   3. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 DEFINITIONS
A. BAS: Building automation system.
B. CWP: Cold working pressure.
C. PTFE: Polytetrafluoroethylene plastic.
D. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS
A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   1. Plans, elevations, sections, and details.
   2. Location and size of each field connection.
   3. Details of anchorages and attachments to structure and to supported equipment.
   4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
   5. Location and arrangement of piping valves and specialties.
   6. Location and arrangement of integral controls.
C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

F. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For cabinet unit 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, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 EXTRA MATERIALS

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. Cabinet Unit Heater Filters: Furnish [one] <Insert number> spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 WALL AND CEILING HEATERS

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:

C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings King W or LPWV or a comparable product by one of the following:

1. Berko Electric Heating; a division of Marley Engineered Products.
2. Chromalox, Inc.; a division of Emerson Electric Company.
3. Indeeco.
4. Markel Products; a division of TPI Corporation.
5. Marley Electric Heating; a division of Marley Engineered Products.
6. Ouellet Canada Inc.
7. QMark Electric Heating; a division of Marley Engineered Products.
8. Trane.
9. King

D. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

E. Cabinet:

1. Front Panel: 3/16” expanded metal plate, with removable panels fastened with tamperproof fasteners.
2. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.

F. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.

1. Motor: Permanently lubricated. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

H. Controls: Unit-mounted thermostat.

I. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

J. Capacities and Characteristics:

1. Heating Coil: 3 kW.
2. Electrical Characteristics for Single-Point Connection:
   b. Phase: 1ph.
   c. Hertz: 60Hz.
   d. Full-Load Amperes: 6.3
   e. Minimum Circuit Ampacity: 6.3

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
E. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

F. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."

G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 23 Section "Steam and Condensate Heating Piping."

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 238239
SECTION 260500 - COMMON WORK RESULTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Division 01 for submittal requirements and formats.

1.2 OUTLINE OF WORK

A. Scope: The work under this division includes furnishing all materials, equipment, labor, supervision, tools and items necessary for the construction, installation, connection, testing and operation of all electrical work for this project as shown on the Electrical Drawings and/or defined in Division 26 of the specifications.

B. Contract Requirements: Comply with the requirements of the General Conditions, the Supplementary Conditions, and Division 01 as they apply to the work in this section. Comply with the requirements of the other specification divisions that have additional requirements for this work as referenced under Division 26 sections.

C. Related Work Described Elsewhere: Where other divisions require electrical materials or installations under this division of the specifications, comply with all applicable requirements herein. Provide all electrical materials and installation work required to connect, test and operate equipment described in other divisions of these specifications as shown on the Electrical Drawings or specified hereinafter. Electrical installations required by other divisions but not shown on the Electrical Drawings or specifically called out in this division of the specifications shall be provided by the trade requiring the electrical work.

D. Itemized Schedule of Costs: Furnish a contract cost breakdown by specification section to the Architect with a copy to the Engineer to allow evaluation of partial payment requests. Refer to Division 01 for requirements.

E. Warranty: The Contractor shall guarantee all work installed under this specification and make good, repair or replace at his own expense, any defective work, materials or parts within the warranty period, if, in the opinion of the Architect, said defect is due to imperfection in material, design or workmanship. The warranty period shall be in accordance with Division 01 but not less than one year. Lamps are not warranted but all shall be operating at time of final acceptance. Warranty shall be submitted in writing as required in Division 01.
1.3 REGULATIONS

A. Codes and Ordinances: Comply with all applicable codes, ordinances and regulations including the National Electrical Code, the Washington Administrative Code, National Electrical Safety Code, WISHA, NFPA, and all other national, state and local codes and ordinances. Notify the Architect of any non-compliance in contract documents to applicable codes and regulations prior to installation of the work. Changes in the work after initial installation due to requirements of code enforcing agencies shall be at no additional cost to the Owner.

B. Permits: Provide and pay for all permits and fees required for this project. In addition to paying for all permits and fees, the Contractor shall be responsible for contacting the various Approving Authorities, arranging for review of shop drawings where appropriate, scheduling inspections in a timely manner, and making necessary corrections as required by the Approving Authorities.

C. Approving Authority: It is the Contractor's responsibility to ascertain and contact the appropriate "Approving Authorities" for this project. Approving Authorities will include, but not be limited to the local Fire Marshal and the local authority having jurisdiction.

D. Certificate of Inspection: Obtain a Certificate of Electrical Inspection from the local inspecting authority indicating final acceptance. Submit to the Owner upon completion of the project as part of project closeout.

E. Safety Measures to be Taken: The Architect and Engineer have not been retained or compensated to provide design and construction review services relating to the Contractor's safety precautions or to means, methods, techniques, sequences or procedures required for the Contractor to perform his work. The Contractor will be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours. The duty of the Architect and Engineer to conduct construction observations of the Contractor's performance is not intended to include review of the adequacy of the Contractor's safety measures, in, on or near the construction site. It shall be the Contractor's responsibility to comply with "Safety and Health Regulations for Construction," Volume 36, No. 75, Part II of the Federal Register by the U.S. Department of Labor. Contractor shall be responsible for providing all such safety measures and shall consult with the state or federal safety inspector for interpretation whenever in doubt as to whether safe conditions do or do not exist or whether he is or is not in compliance all with state or federal regulations.

1.4 DRAWINGS AND SPECIFICATIONS

A. Intent: The Electrical Drawings and specifications are intended to include all labor and materials necessary to provide a complete and operating facility. Any materials shown and called for on the drawings but not mentioned in the specifications, or vice versa, which are necessary for the proper completion of the installation or operation of the equipment, shall be furnished the same as if specifically called for in both. By submitting a bid, the Contractor is acknowledging that he has made a thorough examination of the contract documents, existing site conditions, and has determined that these documents and conditions do sufficiently describe the scope of construction work required under this contract. Any questions regarding interpretation of the contract documents shall be made in writing in a timely manner prior to the bid date to allow reasonable time for resolution of the questions.
B. Diagrammatic Drawings: The Electrical Drawings are diagrammatic and do not show exact or complete raceway and wiring configurations, routing, rating or the necessary number and types of raceway fittings, junction boxes and pull boxes. Provide all labor and materials required to execute the work specified herein or described on the Electrical Drawings.

C. Any minor changes (less that 6’-6” horizontal or vertical) in the location of the raceways, outlets, boxes, devices, wiring, etc., from those shown on the drawings shall be made without extra charge, where coordination requires or if so directed by the Architect prior to rough-in.

1.5 SUBMITTALS AND SHOP DRAWINGS

A. Submittals, General: All equipment must be submitted for review prior to installation. Provide submittals in accordance with Division 01. The remaining instructions in this paragraph are intended to supplement and amplify the requirements of Division 01. Bind submittals in threering binder. Open catalog sheets will not be accepted. Shop drawings shall consist of one reproducible drawing and a maximum of four blueprint sets. Index to the applicable specification section with a transmittal letter bound as the first sheet. Provide an index with each section of equipment indicating exact catalog numbers of products provided. In addition, identify the specific products by catalog number within the submittal documents. Submittals will not be accepted unless they conform to these requirements.

B. Shop Drawings: Provide shop drawings, descriptive bulletins, data sheets, diagrams, catalog cuts or other additional information as required for all specified materials including the following:

<table>
<thead>
<tr>
<th>Submittal Number</th>
<th>Date Reviewed</th>
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<tr>
<td>Raceways and Fittings</td>
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<td>Cable Tray</td>
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<td>600-Volt Wire and Cable</td>
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<td>Outlet, Junction and Pullboxes</td>
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<td>Wiring Devices</td>
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<td>Electrical Identification</td>
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<td>Lighting Controls</td>
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<td>Motor Controls &amp; Misc. Equipment Connections</td>
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<tr>
<td>Emergency Generator</td>
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<td>Switchboards</td>
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<td>Disconnect Switches</td>
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<td>Fuses</td>
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<td>Grounding</td>
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<td>Panelboards</td>
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<td>Transient Voltage Surge Suppressors</td>
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<td>Automatic Transfer Switches</td>
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<td>Lighting</td>
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<td>Dry-type transformers</td>
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<td>Fire Alarm System</td>
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<tr>
<td>Intercom and Master Clock System</td>
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<td>Telecommunications System</td>
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<td>Sound Reinforcement System</td>
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C. Submittal Format: Submittals must be sent in complete "sets," including all specified material. Submission of individual materials will not be accepted.

D. Review: The review of a manufacturer's name or product by the Architect does not relieve the Contractor of the responsibility for providing materials and equipment which comply in all details with the requirements of the contract documents. Contractor shall be solely responsible for submitting materials at such a time to allow a minimum of two weeks for Engineer's review.

E. It is the Contractor's responsibility to thoroughly review vendor-assembled shop drawings, catalog cuts, etc. to ensure that these documents are complete and comply with the specifications. If this coordination effort is not done, the Architect reserves the right to reject the complete submittal without review. To insure compliance with the Architect's review comments and communication of these comments through the Contractor and supplier to the manufacturer, all corrections to shop drawings shall be done by the manufacturer and resubmitted as requested by the Architect. "Local" mark-ups of the manufacturer's shop drawings will not be accepted.

1.6 OPERATIONS AND MAINTENANCE MANUALS

A. Provide operations and maintenance manuals for all electrical equipment installed on this project in accordance with Division 01.

B. Items described shall include, but not be limited to, the equipment listed under "Shop Drawings" in this division of the specifications. Provide table of contents at front of manual indicating general content of each section. Provide index for each section of the manual with complete equipment catalog item or identification.

C. The information and diagrams included must be on the specific equipment installed for this project. General "product line" information is not acceptable. The equipment model and catalog numbers with appropriate prefixes and suffixes must be clearly indicated on the data sheets. Manuals shall contain shop drawings, schematic and wiring diagrams (showing all external connections), parts lists, operating and maintenance information. Any modifications to equipment in the field shall be updated on the drawings, diagrams, etc., to reflect the "as-built" conditions.

D. Binding: Bind with three-screw post-type binder with heavy-duty hardboard cover and cloth backing. Imprint edge of volume with name of the building, year of completion and the words "Electrical Equipment." Front of manual shall be imprinted with the words "Electrical Equipment" the name of the project, the name of the Owner, year completed, name of the Architect, Engineer and Contractor. All printing in gold lettering. If the thickness of the manual exceeds approximately 2", provide separate volumes, each approximately 2" thick with each volume imprinted as described above and with the addition of the volume number. The back edge shall be imprinted with the name of the project, name of the Owner and year of completion.
E. Provide one preliminary copy to the Commissioning Authority for review 30 days prior to scheduled training or project completion, whichever is first. One preliminary copy shall be submitted to the Engineer for review 30 days prior to completion of the project. Placeholders are to be used for information that is not available at the time of draft manual submission. Preliminary copy shall include proposed wording for cover and back edge of the manual. Submit final bound copies for distribution as required by Division 01.

1.7 RECORD DRAWINGS

A. Maintained on Site: A record shall be made during the progress of the project indicating the work as actually installed. Corrections and changes shall be kept up to date at all times on a separate set of record drawings kept at the job site for review by the Architect. Mark-ups may be schematic as related to interior raceway systems, however, all raceways shall be shown in proper relationship with junction boxes, panelboards, devices, and equipment. Raceways installed below grade shall be shown with both horizontal and vertical dimensions at an accuracy of ±6 inches.

B. Project Closeout: Provide one set of prints indicating work as revised, detailed and actually installed, and submit to the Architect as part of the Project Closeout documentation. Panel schedules and fixture/equipment schedules shall also be updated.

C. Additional Record Drawings: Refer to Signal and Communication Systems section for additional record drawing requirements. AutoCAD production requirements also apply to all signal and communications system drawings.

1.8 CONSTRUCTION SCHEDULING AND SEQUENCING

A. Construction will occur in numerous phases. At the completion of each phase the electrical systems shall be tested and the Owner trained in the use of the systems. Refer to Architectural Drawings and the specifications for construction schedules and sequencing requirements.

1.9 ABBREVIATIONS AND DEFINITIONS

A. Provide: To furnish and install.

B. Wiring: Raceway, conductors and connections.

C. Exposed: Visible from occupied areas.

D. Install: To set in position and make fully operational.

E. Furnish: Purchase and deliver to the job site.

F. Required: As required by code, authority having jurisdiction or contract documents for the system and/or installation to be fully operational.
PART 2 – PRODUCTS

2.1 STANDARD OF QUALITY

A. General: Whenever any material or equipment is specified by patent or proprietary name or by the name of the manufacturer, such specification shall establish the standard of quality in that particular field of manufacture. The Architect shall be the sole and final judge as to quality and acceptability of substitutions, no exceptions.

B. Substitutions:

1. Unless otherwise noted on the drawings or other sections of the specifications, the Contractor may offer material or equipment with equal or better qualities than those specified. Reference is made particularly to Instructions to Bidders related to prior approval requirements.

2. When the substitute equipment or material necessitates revisions to the plans or involves other trades, the Contractor shall include drawings and details showing all such changes, and coordinate and assume any liability and costs from the affected trades. Also, if a change required engineering or mechanical services or other equipment modifications, these services shall be billable to the Contractor.

2.2 PRODUCT LISTING OR LABELING

A. All electrical equipment and materials shall have Underwriters' Laboratories, Inc., or other approved testing facility label whenever published standards exist. Equipment in compliance with UL standards but not bearing their label is not acceptable. If the manufacturer cannot arrange for labeling of an assembled unit at the factory, the necessary inspection and acceptance by the testing facility shall be performed in the field at no additional cost to the Owner, and be acceptable to the authority having jurisdiction.

PART 3 – EXECUTION

3.1 GENERAL

A. All materials shall be new, free from defects and arrive at the job site in original unopened containers.

3.2 MATERIAL STORAGE

A. Make all necessary provisions for storing materials and equipment at site so as to insure the quality and fitness of the items to be incorporated in the work. Equipment shall be stored to prevent damage and corrosion.
3.3 WORKMANSHIP AND COORDINATION

A. General: Workmanship shall be the best quality as recognized by the electrical construction industry and satisfactory to the Owner and Architect. Remove and replace lesser quality work as directed at no additional cost to the Owner. The Architect, or his designated representative, shall be the judge of the required quality of workmanship.

B. Work of Other Trades: The Electrical Drawings do not show complete details of the building construction. Refer to the Architectural, Structural, Civil Landscape and Mechanical Drawings for those details which may affect the execution of this work. Specific locations of construction features shall be obtained from the reference drawings, field measurements, or the trade providing the material or equipment. No extra payments will be allowed for failure to obtain this information.

C. The Contractor will not be paid for work requiring reinstallation due to lack of coordination prior to installation i.e., removing, replacing, relocating, cutting, patching or finishing. Special attention is called to the following items and all conflicts shall be coordinated prior to installation:

1. Light switches will be located on the "strike" side of the door.
2. All electrical outlets, lighting fixtures, signal and communications devices, and other electrical devices and equipment are installed to avoid conflict with grilles, pipes, sprinkler heads, ducts and other mechanical equipment.
3. Electrical outlets, lighting fixtures, signal and communications devices and equipment are to be installed in proper relation to cabinets, counters, doors and other Architectural appurtenances.
4. Electrical characteristics (HP, KVA, voltage, phase, fusing, overload protection) of actual equipment furnished under other divisions being different from that shown on the electrical drawings.

D. Cooperation: Plan and execute work in cooperation with all other trades and utility companies. Every reasonable effort shall be made to provide all concerned with timely notice of work affecting other trades, and to prevent conflicts or interference as to space requirements, dimensions, openings, block-outs, sleeving or other matters which will cause delays or necessitate work-around methods.

E. General Construction:

1. Cutting and Patching: Provide all cutting, demolition and patching required for the installation of the electrical work on this project. Patching shall be accomplished by utilizing the general construction trades normally providing materials and labor needed for restoration of floor, ceiling or walls. Penetrations through existing structural walls, ceiling or floor slabs shall be core drilled. Spillage from core drilling shall be contained by diking, vacuuming and covering with protective plastic sheeting as required. In no case shall structural members be penetrated without prior approval of the Architect. After installation of raceways, provide approved fire sealing materials to close spaces around raceways.
2. Sleeves and openings required through floors and walls for electrical work shall be the responsibility of the Contractor. This work shall be carefully coordinated with the General Contractor and other trades involved. All openings around conduits in sleeves shall be sealed with a material of equal fire rating as the material penetrated.
3. Painting: Touch up electrical equipment with factory finished surfaces as required using factory furnished paint. Coordinate field painting requirements with the Architect prior to final trim and cover installation. Do not paint screw heads, hinges, nameplates, hardware, etc. All surface-mounted raceways in finished areas will be painted as directed under the "Painting" division of the specifications. Coordinate timing of installation to minimize conflicts with painting requirements.

4. Cleaning: Promptly remove waste material and rubbish resulting from electrical work. Prior to energizing equipment, remove all chipping materials, construction dirt and debris, vacuum and wipe-down all internal areas. At completion of the project, clean all equipment and fixtures installed under this Contract.

5. All penetrations through building roofing shall be flashed by a qualified roofing contractor normally in the business of commercial roofing. Flashing shall be in accordance with NRCA standard practices.

6. No penetrations shall occur in beams with internal pre-stressed cable design or concrete floor slabs with pre-stressed cabling will be allowed without prior written analysis by a structural engineer.

7. Prevent spillage during hauling operations. In case of spills (including trenching materials) clean streets, walkways, courtyards, etc. by means of proper sweepers or other approved methods.

8. School dumpsters shall not be used by the contractor.

F. Existing Conditions:

1. General: Specific scope of demolition work and operating conditions to be encountered shall be verified by on-site review prior to submitting bid. Demolition work in general is noted or shown on the documents based upon available "drawings of record" and may not show the actual conditions as they presently exist. The Contractor shall be responsible for removing or modifying the existing electrical installation as required by the building alterations. The Contractor shall be responsible for protection of existing equipment and wiring to be retained or reinstalled and shall replace any equipment damaged during the process of removal and reinstallation.

2. Owner Retained Equipment: The Owner may wish to retain certain specific items scheduled for demolition. The Contractor shall carefully remove these items, provide protection and packaging as may be required to protect the equipment and turn over said equipment to the Owner at a place designated on the jobsite. Any equipment that the Owner does not desire to retain shall become the property of the Contractor and be removed from the site.

3. Existing Conduit and Wiring: No existing conduit or wiring shall be reused.

4. Unused Conduit and Wiring: All unused conductors in existing buildings shall be removed. All unused conduit shall be removed except where located in or above existing construction which is not being altered and would require removal and replacement of the existing construction.

G. Continuity of Service To and In Existing Building:

1. Continuity of Service: The Contractor shall temporarily reroute or relocate existing wiring and/or equipment which is in conflict with existing building alterations and which is required to be maintained in use during construction. The Contractor's bid shall include intercepting and relocating existing raceways in 20 different locations throughout the school. Each location shall be assumed to have four ¾" EMT raceways (100 L.F. each), each containing seven AWG conductors which must be intercepted and relocated.
2. Premium Pay: Any overtime work required by this project to maintain the facility in continuous service without reducing its efficiency shall be included as a part of this contract. No additional payments will be authorized for work performed on weekends, holidays or other-than-normal working hours.

3.4 REMOVAL AND REPLACEMENT OF EXISTING MATERIAL:

1. Ceiling Panels: Remove and reinstall all necessary panels in existing accessible ceilings, as required for the installation of electrical work. Where existing ceiling panels are damaged, they shall be replaced with new units. After ceiling removal and reinstallation is complete, the ceiling system appearance shall match adjacent similar ceilings that have not been removed.

2. Work Caused by Removal and Reinstallation of Existing Material: Existing electrical work which is to be removed and reinstalled as a result of the installation of work by other trades shall be performed by the Electrical Contractor at no additional expense to the Owner.

3. Existing fluorescent fixture ballasts to be removed may contain PCB's and are to be treated as hazard materials. Removal and disposal of these fixtures are to comply with all local, state, and federal agency requirements. Provide documentation as required by the regulating agency as proof of proper disposal.

4. Openings in walls and floors resulting from removal of conduits and/or devices are to be patched with materials equivalent to adjacent surfaces. Materials used for patching shall maintain the fire rating of the existing area.

3.5 MISCELLANEOUS

A. Equipment Anchorage, Support and Bracing:

1. General: Provide complete seismic anchorage and bracing for the lateral and vertical support of conduit and electrical equipment, as required by the Uniform Building Code.

2. Conduit Crossing Structural Separations: Conduit that crosses structural or seismic separations between building units shall be installed with flexible connections, suitable to accommodate longitudinal and transverse displacements. Secure raceways each side of joint and provide minimum of 36" length flexible conduit between building units.

B. Phase Relationship: Maintain consistent phase relationship and rotation throughout the project. Check and identify proper rotation of equipment prior to energizing said equipment.

C. Housekeeping Pads: Coordinate size and location of housekeeping pads for all floor-mounted electrical equipment. Pads shall be 4 inches thick (nominal) x 2 inches larger than plan view dimensions of equipment. Provide 1-inch x 1-inch chamfer at top edges of pads.

3.6 CONSTRUCTION OBSERVATION AND FINAL ACCEPTANCE

A. Site Review: On-site meetings or reviews of construction by the Architect, Engineer or Owner shall not be construed as acceptance by these parties as related to quantities, rough-in locations, and compliance with code enforcing authorities unless specific exceptions have been brought to the attention of the Architect or Engineer and have been accepted in writing.
B. **Testing:** The Contractor shall test all wiring and all electrical equipment to verify absence of grounds and short circuits and verify proper operation, rotation, and phase relationship. Contractor will be responsible for scheduling of tests and demonstrations at times mutually acceptable to the Owner. All equipment shall be demonstrated to operate in accordance with the requirements of this specification and the manufacturer's recommendations. Operate every device manually and automatically in accordance with its purpose. Tests shall be performed in the presence of the Owner or his designated representative. All instruments and personnel required to conduct the test shall be provided by the Contractor. Any test not witnessed by the Owner shall be waived by written document. All such documents must become the property of the Owner upon completion of construction.

C. **Commissioning:**

1. Selected equipment and systems are to be commissioned per Section 019100 “General Commissioning Requirements” and Section 260816 “Commissioning for Electrical Systems.” The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

2. Provide copies of all start up documents for systems being commissioned to the Commissioning Authority prior to start of commissioning testing.

3. Provide assistance to the Mechanical Contractor and Commissioning Agent as specified in Section 019113 “General Commissioning and Section 230816 “Commissioning of Mechanical Support Sections.”

D. **Instruction for Owner's Personnel:**

1. Scope: Following initial operation of all electrical equipment and prior to acceptance of the electrical work, conduct demonstrations of equipment operation and instruction periods for the Owner's representatives.

2. Initial Instruction Periods: Shall include preliminary discussion and presentation of information from maintenance manuals with appropriate references to drawings, followed by tours of equipment spaces explaining maintenance requirements, access methods, servicing and maintenance procedures, settings and available system and equipment adjustments.

3. Final Instruction Periods: 30 days after the initial instruction, a second instruction period shall be scheduled. The format and duration of the instruction periods shall be identical to the initial instruction periods.

4. Contractor's representatives, in general, who conduct these instructions and demonstrations shall be qualified foremen or superintendents acquainted with this project and from the trade involved. For major equipment, the representative shall be the manufacturer's representatives with operating experience and substantial design experience on this project. Their qualifications shall be submitted to the Architect and Engineer before conducting the instruction period.

5. Minimum Duration of Instruction Periods:

   a. Electrical Distribution System: 4 Hours
   b. Lighting System: 4 hours
   c. Signal and Communications Systems: 4 Hours each
   d. Refer to other section of the specification for additional testing requirements.
6. Scheduling of Instruction Periods: Provide notice of Contractor's readiness to conduct such instruction and demonstration periods to the Owner at least two weeks prior to each instruction period and reach agreement on the date of each instruction period.

7. Attendance sheets shall be filled out for each training session listing all participants. Copies of the attendance sheets shall be provided to the Commissioning Authority.

8. Prepare a written statement of acceptance for the Owner's signature. The statement shall be substantially as follows:

   "I (the Contractor), the associated factory representatives and the subcontractor, have thoroughly tested each of the following systems and have proved their normal operation to the Owner's representative and have instructed him in the operation and maintenance thereof."

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<thead>
<tr>
<th>Owner's System</th>
<th>Demonstrator</th>
<th>Representative</th>
<th>Date</th>
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<tbody>
<tr>
<td>Electrical Distribution</td>
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<td>Lighting</td>
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<td>Gym/Commons Sound System</td>
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<td>Telecommunications</td>
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   Owner's Representatives Date

   Contractor Date

9. Send copies of this acceptance to the Architect and the Engineer and place one copy in each maintenance manual.

E. Completion of Work: When requesting final inspection, provide ten day notice. Submit written certifications that the work has been fully completed in strict accordance with the plans and specifications.

F. Final Documentation: See STA General Conditions. All manuals, test results, and acceptances by the inspecting authorities shall be included in this final documentation.

END OF SECTION 260500
SECTION 260519 - ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE
   A. Provide all wire and cable required for electrical systems being installed.

PART 2 – PRODUCTS

2.1 PROHIBITED MATERIALS:
   A. Type MC cable, similar to Armor Cable and like material.

2.2 MATERIALS
   A. All wiring shall be Copper and be rated at 600 volts. Aluminum is acceptable for feeders rated
      100 amps or larger.
   B. Wire sizes 12 and 10 shall be solid, Type THHN, Wire sizes 8 and larger shall be stranded, type
      THW,THHN/THWN. Minimum wire size shall be 12 AWG, unless noted otherwise.
   C. Pre-manufactured fixture whips may be used to connect recessed light fixtures in accessible
      ceilings.
   D. Minimum Conductor Size:
      1. Neutral: #10 AWG (#12 AWG minimum for dedicated neutrals and lighting circuits).
      2. Ground: #12 AWG.
   E. Molded connectors with metal thread-on core shall be used for splicing 12 and 10 wire.
   F. Stranded cable shall be connected to lugs using mechanical connectors and shall be wrapped
      with electrical tape to a thickness equal to the wire insulation connecting block.
   G. Splices: For #8 and larger conductors, use molded insulated connector splice block.

2.3 MANUFACTURER
   A. American Insulated Wire Corp, General Cable, Rome, Southwire, or approved equal.
2.4 TERMINATIONS AND SPLICES
   A. Provide insulated screw-on type connectors on lighting and receptacle branch circuit splices; Ideal Wingnut or equal. Self-stripping crimp-pressure-type connectors such as Scotchlock 500 series are not approved. Insulated ring-tongue compression-type terminals (Burndy or T&B) for motor and equipment terminations; hydraulically set compression lugs for terminations at panel and switchboard busses; and Cadweld exothermic type for grounding systems.
   B. Below-grade splices shall be made in handholes and shall be made watertight with epoxy resin type splicing kits. Scotchcast or equal.

2.5 SIGNAL AND COMMUNICATIONS WIRING
   A. All signal and communications wiring is included in the appropriate signal and communications system specification sections.

2.6 CABLE TIES
   A. Shall be Thomas & Betts "Ty-Rap." Provide in switchboards, wireways, panelboards, relay panels and other enclosures to neatly group and lace electrical conductors.

2.7 WIRE PULLING COMPOUND
   A. Manufacturer: Ideal "Aqua-Gel II" or equal.

PART 3 – EXECUTION

3.1 BRANCH CIRCUITS
   A. Branch circuits shall be no. 12 AWG minimum, color-coded as listed below. Homeruns greater than 100 feet to first outlet shall be No. 10 minimum. Use no mechanical means for pulling wire. Make no splices in home runs. Wiring from separate raceway systems shall not be intermixed in common junction boxes. Wiring shown in separate raceway systems shall not be combined unless specifically approved by the engineer.
   B. All circuits shall have separate neutrals. No shared neutrals will be allowed.
   C. Provide separate ground bonding conductor full length inside all conduit.
   D. Where more than three current carrying conductor are installed in a single raceway, the minimum wire size shall be increased to comply with NEC 310-16, Note 8.
3.2 FEEDERS

A. Feeders shall be sized as shown on the drawings and color-coded in accordance with list below. Make no splices unless shown on the plans or specifically approved by the Architect’s representative.

B. Provide separate ground bonding conductor full length inside all conduit.

3.3 COLOR CODING REQUIREMENTS

A. 120/208-volt, 3-phase, 4-wire systems or 120/240-volt, 3-phase, 4-wire systems:
   - Phase A black
   - Phase B red
   - Phase C blue
   - Neutral white
   - Ground green
   - Isolated ground green with yellow stripe
   - Travelers yellow (for 3- and 4-way switching)

B. 277/480-volt, 3-phase, 4-wire systems:
   - Phase A brown
   - Phase B orange
   - Phase C yellow
   - Neutral grey
   - Ground green
   - Travelers lavender

C. Color-coded tape may be used in lieu of color-coded insulation for conductors No. 6 AWG and larger. However, when color-coded tape is used, the conductor insulation shall be black only, and shall be taped at all terminations and junction boxes with color scheme shown above for entire length of exposed conductor. All control wiring shall be black with wire numbers on each conductor at each termination point. Wiring diagrams shall have corresponding wire numbers indicated thereon.

D. System Cabling Type and Color Standards
   
   **EMS System**
   
   Type: Plenum
   Color: White

   Lighting Controls and Occupancy Sensor
   
   Type: As Required
   Color: Orange

   **Security System**
   
   Type As Specified in Section 280500
   Color: Yellow

   **Data Cat 5e**
   
   Type: Non-Plenum
   Color: Blue
   Type: Plenum
   Color: White
Intercom System

Type: Non-Plenum  Color: Gray
Type: Plenum  Color: Gray

E. Color coding shall be approved by the inspecting authority.

3.4 SPLICES AND TERMINATIONS

A. Lighting and receptacle branch circuit conductors up to No. 10 AWG shall be spliced with wing nut type connectors. Motor connections using wiring No. 8 AWG and larger shall be made with crimp-type sleeves or lugs insulated with heat shrink tubing. Feeders shall not be spliced, except in special situations after engineer approval.

3.5 PHASE BALANCING

A. Contractor shall check load on each phase at each panel and service equipment, and make the necessary circuit adjustment to ensure proper balance of load on all three phases.

3.6 HOME RUNS

A. Branch circuit conductors shall be home run to panelboards as shown on the drawings. Combining branch circuit home run conductors in single conduits is allowed up to three current carrying conductors per conduit.

END OF SECTION 260519
SECTION 260526 - GROUNDING AND BONDING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. Refer to Division 01 for submittal requirements and formats.

1.2 GENERAL
A. Provide power grounding system and equipment grounding system in accordance with the applicable codes and ordinances and as further defined on the plans.

1.3 GROUND CONTINUITY
A. Provide through the entire electrical system. A separate green equipment grounding conductor shall be provided in all branch circuits.

1.4 BONDING
A. Insulated grounding bushings shall be installed to bond all feeder conduits to the switchboard ground bus or panel ground bus at both ends of feeder raceways. Insulated grounding bushings shall also be installed in all feeder pull boxes to bond all conduits together. Jumpers or bonds shall be copper and sized in accordance with Table 250-95 of the National Electrical Code.

1.5 NEUTRAL GROUNDING
A. The neutral point of all radically operated transformers shall be solidly grounded to the grounding system and transformer enclosure with code size ground conductors. The neutral bus in each panelboard shall be isolated from ground. The neutral shall be grounded only at a single point at the main switchboard or at separately derived system transformers.

1.6 SIZE OF GROUND WIRE
A. In all cases, shall not be less than that required under National Electrical Code requirements.

1.7 RECEPTACLE GROUNDING
A. Connect the ground terminal of all receptacles by utilizing a separate grounding conductor between the receptacle grounding screw and the ground conductor provided in the branch circuit. Integral mounting straps within the receptacle connected to the device mounting straps are not approved as a grounding method.
1.8  FLEXIBLE CONDUIT GROUNDING
   A. Provide a separate grounding conductor in all flexible conduit runs including watertight flexible conduit with integral grounding straps. Install ground conductor inside conduit with ungrounded conductors.

1.9  PVC CONDUIT GROUNDING
   A. Provide a code size green grounding conductor the full length of the feeder or branch circuit when PVC is used in whole or in part.

1.10 GROUND CONNECTIONS
    A. Ground connections to building steel, ground rods and cable taps shall utilize an exothermic welding process.

PART 2 – PRODUCTS

2.1  GROUND CONDUCTORS:
    A. Copper conductors in accordance with Section 260526 “Grounding and Bonding.”

2.2  EXOTHERMIC CONNECTIONS

2.3  INSULATED GROUND BUSHINGS
    A. Malleable iron with insulated ring and ground clamp. Steel City or equal.

2.4  COMPRESSION CONNECTIONS
    A. Non reversible compressions – listed hydraulically-crimped fittings

2.5  GROUND RODS
    A. 3/4" x 10'-0" long. Copper clad steel.
PART 3 – EXECUTION

3.1 INSTALLATION

A. Provide main grounding busbar for telephone/data, intercom, television system head end equipment. Grounding conductor for telephone/data, intercom, television system main grounding busbar shall be #6 AWG, 600 volt, insulated copper conductor.

B. Bond all telecommunication equipment chassis, ladder racks, cable trays, conduits, equipment frames, cabinets, and all other telecommunications room and equipment room metallic components to the main grounding busbar.

C. Install ground rod vertically, with top flush with ground level unless physically protected. Connect to water service on street side of main shutoff valve, building structural steel, and service transformer ground rod.

D. Install ground rod at each transformer and make connection to all exposed metal parts.

E. Provide exothermic or braze all concealed or below grade connections. Provide exothermic connections to building steel.

F. Compression connections shall be made using a hydraulic 4-way compression die. All compression connections shall be exposed.

G. Provide separate ground conductor the full length of all raceways.

3.2 GENERAL TERMINATIONS

A. Burnish to bare metal under all grounding and bonding terminations to assure good ground continuity. Terminations are to be attached with separate screw and nut. When more than one termination is required, provide a separate ground terminal strip.

3.3 DEVICE OUTLET BOX

A. Provide separate grounding conductor between the outlet box containing the device and the branch circuit grounding conductor.

END OF SECTION 260526
SECTION 260529 - HANGERS AND SUPPORTS

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 DEFINITIONS
   A. EMT: Electrical metallic tubing.
   B. IMC: Intermediate metal conduit.
   C. RMC: Rigid metal conduit.

1.3 SUBMITTALS
   A. Product Data: Submit for each of the products provided.

PART 2 – PRODUCTS

2.1 SUPPORT, ANCHORAGE AND ATTACHMENT COMPONENTS
   A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
   B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      1. Cooper B-Line
      2. Thomas & Betts
      3. Unistrut
   C. Metallic Coatings: Hot-dip galvanized after fabrication.
   D. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating.
   E. Painted Coatings: Manufacturer's standard painted coating.
   F. Channel Dimensions: Selected for applicable load criteria.
   G. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
H. 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 malleable iron.

I. 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. Subject to compliance with requirements, provide products by one of the following manufacturers:
   a. Hilti
   b. ITW Ramset/Red Head
   c. Simpson Strong-Tie

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used. Subject to compliance with requirements, provide products by one of the following manufacturers:
   a. Cooper B-Line
   b. Hilti
   c. ITW Ramset/Red Head

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.

PART 3 – EXECUTION

3.1 APPLICATION

A. Conduit Crossing Structural Separation: Conduit that crosses structural or seismic separations between building units shall be installed with flexible connections, suitable to accommodate longitudinal and transverse displacements. Secure raceways each side of joint and provide minimum of 36 inches length flexible conduit between building units.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 3/8 inch in diameter.
C. 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. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. 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 low-voltage systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. 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.

B. 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. In lieu of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete four inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than four inches thick.
5. To Steel: Beam clamps.
6. To Light Steel: Sheet metal screws.

C. 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.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 CONCRETE BASES

A. Provide four-inch high concrete pads with chamfered edges for all floor-mounted equipment including switchboards, distribution panels, transformers, motor control centers and unit substations.

B. Construct concrete bases of dimensions indicated but not less than four inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
C. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section.

D. Anchor equipment to concrete bases.

END OF SECTION 260529
SECTION 260533 - RACEWAYS AND FITTINGS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE

A. Provide complete raceway systems as shown on the drawings and/or as required for proper installation of the various electrical systems being installed under this project. Minimum raceway size shall be ½” for power and ¾” for systems and data unless noted otherwise.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Raceways: Allied, Carlon, Western or equal.
B. Fittings: Appleton, Carlon, T&B, Steel City, O-Z/Gedney or equal.
C. Conduit Straps: Appleton, Carlon, T&B, Steel City, O-Z/Gedney or equal.
D. Low-Voltage Cable Supports: Caddy or equal.

2.2 RACEWAYS

A. Rigid Aluminum Conduit: Not Permitted.
B. Rigid Metallic Conduit: Zinc-coated steel with full threaded connections.
C. Electrical Metallic Tubing (EMT): Zinc-coated steel.
D. Rigid Nonmetallic Conduit: Rigid PVC, Schedule 40, UL listed for direct burial or concrete encasement.
E. Flexible Metallic Conduit: Galvanized steel, securely interlocked.
F. Liquidtight Flexible Metallic Conduit: Galvanized steel, interlocked, with integral ground conductor and PVC jacket overall.
G. Surface Raceway – Steel wiremold product (or approved), ivory in color.
2.3 FITTINGS

A. Rigid Metallic Conduit:
   1. Couplings: Threaded metallic type of the same material as the conduit.
   2. Locknuts: Steel up to 2 inches, malleable iron for 2-1/2 inches and larger.
   3. Bushings: Bakelite or plastic up to 2 inches, malleable iron with insulating collar for 2-1/2 inches and larger.
   4. Unions: Zinc plated malleable iron, 3 piece conduit coupling. Running threads are not acceptable.

B. Electrical Metallic Tubing (EMT): Fittings shall be raintight type steel set screw type containing dual setscrews on each side of coupling. Set screws shall be steel. Cast metal will not be accepted.

C. Rigid Nonmetallic Conduit: Slip-on, nonthreaded type of same material as conduit. Provide rigid steel bends in conduit runs.

D. Flexible Metallic Conduit: Galvanized steel, one- or two-screw clamp type. All fittings shall be steel.

E. Liquidtight Flexible Metallic Conduit: PVC waterproof cover over steel conduit, steel compression type. PVC waterproof flex without steel core is prohibited.

F. Expansion Fittings: Provide expansion fittings for all rigidly fastened conduits spanning a building expansion joint, and for all runs 1-1/2” or larger exceeding 150 feet in length. Fittings shall be hot-dipped galvanized malleable iron with a packing ring to exclude water, a pressure ring, and a separate external copper bonding jumper.

2.4 CONDUIT STRAPS

A. Heavy-duty one- or two-hole pressed steel straps. "Nail-in" style straps shall not be used.

2.5 SURFACE RACEWAY ANCHORS

A. 2-hole strips shall utilize Powers Poly-Toggle Cat #2305.

2.6 LOW VOLTAGE OPEN CABLING SUPPORTS

A. J-Hooks: Shall comply with TIA requirements for structured cabling system. Galvanized finish. Caddy #CAT21 with CATHBA angled hanger bracket. Provide all hardware necessary for secure mounting to the structure. Follow manufacturer’s recommendations for quantity of cables supported.

B. Adjustable Cable Support: Shall comply with TIA requirements for structured cabling system. Caddy #CAT425. Follow manufacturer’s recommendations for quantity of cables supported.
C. Provide all accessories and mounting hardware required for a complete and working installation of open cabling supports.

PART 3 – EXECUTION

3.1 COORDINATION

A. The Contractor shall review all drawings, details and elevations and coordinate with the Architect prior to rough-in, all installations of wiring devices and equipment. Where equipment is furnished by others, the Contractor shall ascertain the proper voltage, load and connection requirements prior to rough-in.

3.2 MATERIALS

A. All materials of a specific type shall be provided by the same manufacturer throughout the project. These products shall be identical to those submitted for review.

3.3 RACEWAY INSTALLATION

A. Raceway Types: Install raceway types and sizes as listed below:

1. Rigid Metallic Conduit: In concrete, masonry, exposed exteriors and exposed interiors where subject to physical damage and as required by code enforcing agencies.
2. Electrical Metallic Conduit (EMT): All areas other than above. May be used for feeders with integral green ground conductor.
3. Flexible Metallic Conduit: Recessed fixture connections, interior concealed equipment connections, expansion and seismic joints and sound control. Not to be used for exposed installations within the building.
4. Liquidtight Flexible Metallic Conduit: Exterior equipment connections and exposed installation within the building.
5. Rigid Nonmetallic Conduit: Exterior underground installations; direct buried for lighting raceways, 90° elbows to be rigid galvanized steel. Service raceways are to be concrete encased. Underground feeders; concrete encased with rigid steel conduit elbows.
6. Surface mounted raceway: Shall be used only where other routes are unavailable and where it is mutually agreed to be desirable by the contractor and owner.
7. See referenced Signal and Communications specification sections for raceways associated with these systems.

B. Installation:

1. Planning: The layout of all raceways shall be carefully planned by the Contractor to ensure an installation which is neatly done and workmanlike. Any work showing improper care in planning will be ordered removed by the Architect, and shall be replaced in a neat and proper manner, without any additional cost to the Owner.
2. Concealment: All raceways shall be concealed in finished areas unless approved otherwise by the Architect. Where existing wall surfaces are inaccessible, surface metal raceways for these exceptions may be provided when approved by the Architect.
Raceways may be surface mounted in unfinished equipment spaces such as mechanical rooms, electrical rooms, elevator machine rooms, and attic spaces.

3. Cutting and Bending: Raceways shall have smooth interior, ends cut square and reamed. Bends shall be carefully made to avoid injuring or flattening raceways (no "Hickey" bends).

4. Exposed Raceways: Install exposed raceways as high as possible, above ductwork, parallel or at right angles to building lines.

5. Expansion and Earthquake Joints:
   a. Raceways shall not be installed in concrete slab or wall construction when passing through an expansion or earthquake joint.
   b. Raceways shall be installed in furred or suspended ceiling spaces with a minimum of 36 inches of flexible conduit crossing the expansion or earthquake joints. Secure raceways each side of joint.

6. Routing: All raceways shall be installed parallel or at right angles to the building construction unless prohibited by a physical obstruction. This applies to all exposed raceways as well as all raceways above suspended ceiling.

7. Raceway Supports: Raceways shall be supported with heavy-duty, one- or two-hole, pressed steel straps on interior surfaces. Support pendant-mounted raceways on 3/8-inch rod with pear-shaped hanger or trapeze-type hanger with 3/8-inch rod (minimum) and 1-5/8-inch square preformed channel and pipe clamps. Parallel, surface-mounted raceways shall be supported from 1-5/8-inch square preformed channel and pipe clamps. All fittings and supports shall be hot-dip galvanized in exterior areas. Preformed channel in areas above suspended ceilings may be standard painted finish. Multiple conduit runs shall be grouped and neatly racked on trapeze hangers.

8. Anchorage: Anchor to metal stud structures by means of sheet metal screws or manufactured spring steel clips. Fasten individual raceways supports to structural walls or slabs with steel expansion shells and bolts. Provide flush concrete insert for multiple raceway support system. Fasten to structural steel with heavy-duty beam clamps. Fasten to architectural or masonry walls with toggle bolts or molley screws.

9. Independent Support: Conduits shall not be supported from the ceiling suspension system, ducts, pipes or other systems foreign to the electrical installation. The entire electrical installation shall be kept independent from any other trade.

10. Suspended Ceiling: Branch circuit raceways and outlet boxes installed above suspended ceilings may be secured to No. 9 AWG or larger support wires that are independent of the ceiling suspension system under the following conditions:
   a. Raceways and cables are not larger than 3/4" trade size.
   b. No more than two raceways or cables are supported by a support wire.
   c. Raceways and cables are secured to the support wires by fittings designed and manufactured for the purpose.
   d. The support wires are securely fastened to the structural ceiling and to the ceiling grid system.
   e. The raceways or cables serve equipment that is located within the ceiling cavity or is mounted on or supported by the ceiling grid system.
   f. Where not prohibited by the building code officials.

11. Conduit Location: Conduit shall not be run under heavy equipment, footings or other structural elements that might adversely affect the integrity of the raceways system or
building footing. All raceways installed above suspended ceilings must be kept a minimum of 6" clear above top of ceiling system.

12. Floor Slabs and Columns: Conduits installed in structural floor slabs shall be coordinated with structural steel and shall be routed to provide a maximum concrete cover. In general, conduit shall not be installed in structural columns, unless special permission is granted by the Architect.

13. Pullboxes with Covers: Shall be provided as shown on the drawings or as required by Code. All pullboxes shall be located so as to be accessible.

14. Flexible Conduit: Shall be used only for lighting fixture pigtails in accessible ceilings, flush-mounted speaker pigtails in accessible ceilings, sound control, motor connections and at building expansion joints as specified. Installations shall not exceed 6'0" in length. Any other proposed use of flexible conduit must be approved by the Architect's representative.

15. Metallic raceway shall be continuous and bonded/grounded. Transitions to ceiling, crawl or tunnel spaces are to be made from a junction box on the "concealed space" side of the penetration.

16. Conduit Stubs: Conduit which stub-up through the floor shall be installed at such a depth that none of the curved section of the elbow is visible.

17. Sealing: All conduit, sleeves, blockouts or openings around raceway and cable systems that penetrate building walls, floors and ceilings shall be sealed. Sealing materials shall be fire-rated, non-combustible type, specifically designed for this type of installation and shall be approved by the authority having jurisdiction.

18. Penetrations: Raceways which pass through building roof, exterior walls of building above or below grade and floor slabs on grade shall be sealed on the interior side of the building using non-hardening sealing compound after all conductors have been installed in the raceway. Sealing material shall be specifically designed for electrical wiring systems.

19. Conduit Passing Through Building Roof: Provide a 4 lb. lead plumbing vent flashing with a counterflashing attached above using a galvanized steel clamp. Flashing shall be in accordance with NRCA standards practices.

20. Conduit Penetrating Membranes: All conduits penetrating walls or slabs with membranes shall be installed with approved membrane clamping devices in order to provide necessary seal.

21. Exterior Walls: Conduits passing through exterior walls below grade and/or bridging an area which was previously excavated and backfilled shall be rigidly supported by a structurally reinforced concrete duct bank spanning between the building wall and a bearing surface on undisturbed earth.

22. Cleaning of Raceways: The interior and exterior of all conduits and other raceways shall be thoroughly cleaned of all material. All conduits shall be capped or plugged after installation to ensure that they remain clean.

23. No section of conduit shall be longer then 100 feet or contain more than three (3) 90 degree bends between pull points or pull boxes.

24. Rigid non-metallic conduit shall not be used in above grade floor slabs, or in wall or open spaces of any type.

25. Electrical metallic tubing (EMT): EMT shall be used in concealed spaces. EMT may not be used in finished areas unless indicated on the drawings. EMT may be used for exposed work in unfinished areas where not exposed to physical damage. Raceways in traffic areas shall be considered exposed to physical damage where within 10 feet of floor. If used in finished areas, must be painted to match existing wall/surface color.

26. Multiple rows of suspended conduits shall be supported from Trapeze style hangers, providing 20% spare room for future raceways.
27. Rigid non-metallic conduit installed underground shall be buried a minimum of 24” and a
maximum of 30” under grade.
28. Utilize rigid steel conduit below all roadways. Installed at depths less then 24” conduit
shall be encased in conduit. Over 24” depth, wrap with scotch insulation tape, or utilize
conduit with factory applied PVC coating.
29. Raceway shall be installed with a minimum separation of 12 inches of free air from steam
and hot water piping and a minimum separation of 3 inches of free air space from all
other mechanical piping.

C. Dissimilar Materials: Keep electrical conduits free from contact with all other piping runs of
different systems or of dissimilar metals.

3.4 RACEWAYS AND CABLE INSTALLATION PATHWAYS FOR LOW VOLTAGE
SYSTEMS

A. Installation of Raceways/Pathways for intercom, clock, telecommunications and CATV
systems shall be in accordance with the applicable portions of ANSI/TIA/EIA-569-A,
Commercial Building Standards for Telecommunications Pathways and Spaces.

B. Conduits above lay-in ceilings: Do not install cables in conduits that are supported from the
ceiling suspension system. All conduits shall be supported independently of the ceiling support
system.

C. Minimum size is ¾” for systems and data, unless noted otherwise. Conduit fill shall not exceed
40%.

D. Bend radii for conduits shall meet the following requirements:

1. If the conduit has an internal diameter of 2 inches or less, the bend radius must be at least
6 times the internal conduit diameter.

2. If the conduit has an internal diameter of more than 2 inches, the bend radius must be at
least 10 times the internal conduit diameter.

E. There shall be no more than two 90 degree bends between pull points in telecommunications
conduit, without derating of the conduit capacity. For each additional 90 degree bend the
conduit capacity shall be derated by 15 percent. Increase conduit size as required to meet
conduit fill requirements of this section with the derated capacity accounted for. Or, provide
pull boxes to eliminate 90 degree bends as necessary to avoid having to derate conduit. Offsets
shall be considered as equivalent to a 90 degree bend. Pull boxes added to conduit runs as of
result of this requirement shall be in accordance with this section.

F. Conduits which are terminated at cable trays shall be supported from structure with a maximum
distance of 24” from the tray. Conduits terminated at cable trays shall be bonded to the tray.

G. Exterior conduit shall be Schedule 40 PVC for Service Entrances. Interior conduit for vertical
riser cable shall be GRC, sized per ANSI/TIA/EIA-568-A-5 or as indicated on the Contract
Drawings. Interior conduit for horizontal cable shall be EMT, sized per ANSI/TIA/EIA-568-A-5
standards or as indicated on the Contract Drawings.
H. Use of flexible conduit for telecommunications shall be kept to a minimum and shall be at the discretion of the Contracting Agency. Obtain prior written approval for the use of flexible conduit. Where required due to physical considerations, flexible metal conduit may be allowed in lengths not exceeding 4 feet. If used, flexible metal conduit shall be increased by one trade size for the application used.

I. Conduits entering the MDF room through the floor shall be terminated 4 inches above finished floor. Conduits entering the MDF room from above shall be terminated 4 inches below the finished ceiling, but in no case shall the conduits terminate greater than 12 inches above the cable tray or distribution frame.

J. Conduits and cut-out openings between floors shall be sealed with firestopping material which is removable and reusable, to accommodate adds, moves and changes in the cabling system.

K. All conduits used for routing of low voltage cables shall have bushings at all stubouts.

3.5 OPEN CABLE SUPPORT AND INSTALLATION PATHWAYS

A. Where cables are indicated to be installed as “Open Cabling”, cable supports (D-rings, J-hooks, adjustable straps, and saddles as appropriate) shall be installed to allow cabling to be grouped and run along a common path. Cables shall be run parallel or at right angles to the building structure, and shall not be looped diagonally across the ceiling space. Cables shall be loosely bundled with cable ties at minimum every 30 inches on center. Provide cable ties at closer intervals where called for on drawings. Provide plenum rated Teflon cable ties in spaces used to handle environmental air.

B. Do not support cables from ductwork, sprinkler piping, water piping, waste piping or electrical conduit.

C. Fire seal around all cables running through rated floors and walls in accordance with Section 260500 “Common Work Results.”

END OF SECTION 260533
SECTION 260540 - OUTLET, JUNCTION AND PULL BOXES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE
   A. Provide all outlet, junction and pull boxes required for proper installation of electrical equipment being installed under this work.

1.3 COORDINATION
   A. The Contractor shall review all drawings, details and elevations and coordinate with the Architect and equipment supplier prior to rough-in, all installations of wiring devices and equipment. Where equipment is furnished by others, the Contractor shall ascertain the proper voltage, load and connection requirements prior to rough-in.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
   A. Boxes: Appleton, Circle AW, Crouse-Hinds, Raco, Steel City, Wiremold or equal.
   B. Fittings: Appleton, Circle AW, Crouse-Hinds or equal.
   C. Floor Boxes: Wiremold, FSR, or equal.

2.2 OUTLET AND DEVICE BOXES
   A. Interior Surface-Mounted in Unfinished Areas: One-piece pressed steel, electro-galvanized, size and depth required by Code, except 4-inch square or 4-inch octagonal minimum. Minimum 14 U.S. gauge, with return flange and screw retained cover.
   B. Interior Flush-Mounted: Galvanized pressed steel, knockout type, not less the 4” square, 2-1/8” deep, minimum 14 U.S. gauge, with return flange and screw retained cover. Provide extension rings for all flush boxes. Boxes which occur in concrete block walls shall be equipped with 1 1/2” square cornered tile extensions.
   C. Interior Surface-Mounted, Finished Areas: Wiremold No. 5700 Series sized to fit standard wiring device, covers specified below.
D. Outlet boxes installed in surface metallic raceway systems shall be shallow boxes manufactured as part of the system.

E. Exterior Mounted: Cast, non-ferrous metal with threaded hubs required. Manufacturers as listed above.

F. Prohibited Materials: Sectional outlet boxes shall not be utilized.

2.3 JUNCTION AND PULL BOXES

A. 100 cubic inches or smaller: Standard outlet box with stamped knockouts.

B. 150 cubic inches or larger: Code gauge steel with sides formed and welded, with screw covers unless shown to have hinged doors. Hinged doors shall have locking device same as furnished for panelboards.

C. Knockouts shall be factory stamped, or formed in the field with a cutting tool to provide a clean symmetrically-cut hole.

D. Interior Areas: Steel, screw cover, Code gauge and size, baked enamel finish.

E. Exterior or Wet areas: Weatherproofed galvanized steel construction with proper gaskets and corrosion resistant fasteners.

F. Device outlets shall be a minimum of 2-1/8” inches deep, minimum 4 inches square.

G. For existing walls, use 2 ½” deep min. cut in box.

H. Prohibited materials: “Handy Boxes”

2.4 FITTINGS

A. Junction boxes or elbows may be cast conduit fittings at Contractor's option. Provide one size larger than raceway for feeders - "mogul-type." Openings accessible at all times. Exterior areas to be cast aluminum with gasketed non-ferrous covers.

2.5 LIBRARY/MULTI-PURPOSE ROOM FLOOR BOXES

A. Recessed steel floor box with all accessories and gangs required to mount the receptacle and communications outlets shown on the drawings. Floor box cover shall be flush with top of finished floor. Cover shall be suitable for floor covering in room. Manufacturer: Wiremold RFB Series with metallic mop-tight flush cover. For tile floors provide plywood filler panel inside cover such that tile is flush with top of the cover. Secure plywood to coverplate with construction adhesive.
2.6  KITCHEN FLOOR BOXES

A. Above-floor, heavy-duty, die-cast aluminum frame, brushed aluminum housing, stainless steel faceplate pedestal-style fitting mounted on a floor box cover with all accessories required to mount receptacles shown on the drawings. Supporting floor box shall be as described in Section 2.5. Manufacturer: Hubbell SC3098A.

PART 3 – EXECUTION

3.1  GENERAL

A. Boxes shall be supported securely and independently. Mount boxes on building surfaces or support with trapeze hanger as described in Raceway Installation. Junction boxes shall not be used unless the number of bends, pulling length, or circuit requirements necessitate their installation. Junction or pullbox openings must be accessible. All boxes must be supported independently of any other building system.

B. Coordinate and locate boxes to ensure accessibility of electrical wiring.

3.2  DEVICE BOXES

A. Outlet and device boxes mounted in stud walls shall be attached to two adjacent wall studs using blocking material behind the box to ensure that the box will remain square to the finished wall surface.

B. Outlet and device boxes mounted in masonry walls shall be set at the bottom or top of a masonry unit course.

C. Plaster rings shall be provided for all devices in walls with finished materials such as gypsum wallboard, plaster, etc. Plaster ring shall extend outlet box to within 1/8-inch of finished wall surface including all wall coverings. Coordinate with Architectural finishes prior to rough-in.

D. Grout around all outlet boxes to seal space between box and wall or ceiling materials.

E. Exterior Wall Outlets: Conduit shall not enter the bottom of exterior wall outlet boxes. Conduit shall enter the sides and top only.

F. Multiple Gang Outlet: Install two or more wiring devices shown in one location under a common plate except when outlets are of a different voltages such as telephone and duplex receptacles. Install plates with all edges in continuous contact with finished wall surfaces. Install plates vertically with alignment tolerance of 1/16-inch. Sectional plates are not permitted. No more than one device shall be installed in a single-gang position.

G. Device Locations: Locate switches 6 inches from door casing unless otherwise shown. Outlets mounted above one another shall be on the same centerline. Coordinate exact locations of any special devices with Architect. All outlet heights must comply with all handicap accessibility requirements. Heights to center of outlet mounted vertically shall be as follows unless otherwise shown:
1. Convenience Outlets: +18"
2. Above Counter Outlets: Verify height. Minimum clearance one inch above backsplash or counter as applicable.
3. Switches: 4'-0"
5. Where different type devices occur adjacent to each other, space outlet boxes so that finish plates will be spaced a minimum of one inch apart at same height.

3.3 BLANK COVERS
A. Provide blank covers or plates over all boxes that do not contain devices or are not part of an equipment connection.

3.4 LABELING
A. All junction and pull boxes in accessible ceiling spaces and exposed in unfinished areas shall be identified to indicate the branch circuit numbers, feeders, or signal and communication system contained within. Use permanent label. Fire Alarm System shall be red color. Refer to Section 270500 “Common Work Results for Communications” for requirements pertaining to Signal and Communication System.

3.5 JUNCTION OR PULL BOXES
A. No box shall be secured to the ceiling system, HVAC ductwork, or mechanical piping.
B. Pull and junction boxes shall be installed as shown or as necessary to facilitate pulling of wire and to limit the number of bends within code requirements. Boxes shall be permanently accessible and shall be placed only at locations approved by the Architect. Secure boxes rigidly to the building element on which they are mounted, or solidly embed boxes in concrete or mansonry. Identify all pull and junction boxes with a permanent label, neatly showing the individual feeder or electrical system. Installations shall only be above accessible ceiling, crawl spaces, tunnels and in unfinished areas only.

3.6 SOUND CONTROL
A. General: The installation of outlet boxes and conduit shall utilize installation methods which minimize sound transmission from one room to adjacent rooms or areas.
B. Installation: Where boxes are mounted in a common wall, they shall wherever possible, be offset horizontally so that they are not mounted back to back. Connect offset boxes with EMT conduit not to exceed 18 inches in length. Where it is not practical to offset boxes, with permission they may be mounted back to back with a minimum clearance of 1/4-inch between boxes and with a sheet of high-density fiberglass between boxes.
3.7 EXTENSION RINGS

A. A maximum of one extension ring shall be provided on each junction box.

END OF SECTION 260540
SECTION 260553 - IDENTIFICATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE

A. Provide proper identification of all electrical work specified. This shall include but not be limited to the following items: service and distribution equipment, starters, disconnects, cabinets, terminal boxes, device junction boxes, danger signs, maintenance access points, and fused switches including fuse size and type.

B. Install nameplates on all main and distribution switchboards, panelboards, disconnect switches, and miscellaneous systems junction boxes and cabinets installed under this contract.

C. Install bakelite nameplates at each protective device in switchboard and distribution centers, showing circuit service.

D. Install circuit directory cards in all panelboards. Cards shall be typed or computer printed.

E. All wiring in all outlet and junction boxes shall be properly identified as to circuit number. Type of marker shall be made with Brady ID Pro printer/labeler with ¾” labels, or approved equal. Locate label on inside of device box. Label shall be black letters on white background using Brady #42019 tape and #42011 ribbon.

PART 2 – PRODUCTS

2.1 MATERIALS

A. Prohibited Materials

1. Dymo (or equivalent) labels shall not be utilized, unless specifically noted.

B. Schedules – provide typewritten directory for each panel, on heavy card stock, showing all circuit numbers.

2.2 EQUIPMENT NAMEPLATES

A. Nameplates shall be fabricated from white bakelite, with 3/8” engraved black letters.
B. Mounting: Nameplates shall be attached with a minimum of two 6-32 roundhead screws, lockwasher and nuts in exterior locations and contact-type permanent self-adhesive in indoor locations.

2.3 SWITCHBOARDS AND DISTRIBUTION PANELBOARDS

A. General: Provide nameplate which identifies the switchboard/distribution panel and the source panel. (Example: Distribution Panel No. 1/Fed from Main Service Switchboard - Bkr. No. 1.)

B. Overcurrent Devices: Provide nameplate at each overcurrent device that identifies the device number and the load served. (Example: Bkr. No. 1/Panel A.)

2.4 PANELBOARDS

A. Provide nameplate on the front of the panel room which identifies the panel. (Example: Panel A.) Provide a nameplate concealed behind the door which identifies the panel, and the source panel. (Example: Panel A, Fed from Distribution Panel 1-Bkr. No. 2)

2.5 DISCONNECT SWITCHES AND MOTOR STARTERS

A. Provide nameplate which identifies the source panel, load served and the fuse size where applicable. (Example: Panel A-1,3,5/Exhaust Fan No. 1/10 amp, RK1 fuses.)

2.6 JUNCTION AND PULL BOX IDENTIFICATION

A. Mark the cover of all junction boxes and pull boxes to identify the system, circuits, or feeders contained within the box. Use red color for fire alarm. Circuits shall be identified by panelboards and specific circuit numbers contained within the junction box. Refer to specification Section 260540 “Outlet, Junction and Pull Boxes” and Section 270500 “Common Work Results for Communications.”

PART 3 – EXECUTION

3.1 INSTALLATION

A. Clean all surfaces prior to installing labels. Where identification is to be applied to surfaces which require finish, install identification after completion of painting.

B. Nameplates

1. Panelboards: Mount inside door, on dead front, above circuit breakers, unless panelboard is located in a utility-type room, then install nameplate on outside of panelboard above door.

2. Disconnect switches: Mount nameplate on outside of cabinet, near top. Omit nameplate from disconnect switches if located adjacent to equipment.
C. Schedules
   1. Panelboards: Mount in frame under plastic cover, on back side of door. Schedule shall be typed or printed and show circuit service for each circuit breaker, using room numbers. Spares and spaces shall be written in pencil.

3.2 REGULATIONS
   A. Comply with governing regulations and requests of governing authorities for identification of electrical work.

3.3 DANGER AND WARNING SIGNS
   A. General: In addition to installation of danger signs required by governing regulations and authorities, Contractor shall be responsible for installing appropriate danger signs at locations constituting danger for persons in or about project.
   B. High Voltage: Install danger signs wherever it is possible, under any circumstances, for persons to come into contact with electrical power.

END OF SECTION 260553
PART 1 - GENERAL

1.1 SCOPE OF WORK

A. Responsibilities and participation in the commissioning process shall comply with the requirements of specification Section 019113 “General Commissioning Requirements.”

B. The subcontractor representing this DIVISION OF WORK shall designate one person as the ‘Commissioning Coordinator’ (CC). The CC shall represent their company and participate as a member of the project ‘Commissioning Team’. The subcontractor shall also designate a backup person to fill the role as CC whenever the designated CC is absent. CC responsibilities are specified in Section 019113 “General Commissioning Requirements.”

C. Testing and acceptance criteria specified in this DIVISION OF WORK shall be coordinated with the approved equipment/product submittals and Commissioning Authority (CxA) Pre-Functional Check (PFC) & Functional Performance Test (FPT) documentation requirements.

D. Building components, equipment, and systems to be commissioned are listed in specification Section 019113 “General Commissioning Requirements.”

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION 260816
SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 – GENERAL

1.1 SCOPE

A. Devices and sensor covered in the section are stand alone and do not necessarily interface with devices covered in Section 260943 “Network Lighting Controls.”

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

A. Product Data: Submit for each type of product provided.

1.5 COORDINATION

A. 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 system, and partition assemblies.

1.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up or testing of equipment. Refer to Section 019113 “General Commissioning” for a list of commissioning activities.

B. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.
PART 2 – PRODUCTS

2.1 TIME CLOCKS

A. Manufacturers: Subject to compliance with requirements, provide products by Intermatic unless otherwise specified.

B. Electronic Time Clocks: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Rating: 30-A inductive or resistive, 240-volt ac.
2. Program: 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.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
4. Astronomic Time: All channels.
5. Battery backup is required for schedules and time clock.

2.2 OCCUPANCY SENSORS

A. Manufacturer: Subject to compliance with requirements, provide products by Lighting Control System Manufacturer identified in Section 260943 “Network Lighting Controls” unless otherwise specified.

B. General Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of one to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-volt ac, for 13-A tungsten at 120-volt ac, and for one hp at 120-volt ac. Power supply to sensor shall be 24-volt dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. 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.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.

C. Dual-Technology Type: Wattstopper DT-300 series (ceiling mount), Wattstopper DT-200 series (wall mount) with separately wired power pack and isolated relay output or approved.
D. Ultra-Sonic Type: Ceiling-mounted Wattstopper UT-300 series with separately wired power pack and isolated relay output or approved.

E. Occupancy Sensor Switches:
   1. Toilet Rooms: Wattstopper UW-100 for controlling one circuit; Wattstopper UW-200 for controlling two circuits.
   2. All Other Rooms: Wattstopper PW-100 series.

2.3 WALL-BOX DIMMERS

A. Manufacturer: Lutron or approved.

B. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches with audible frequency and EMI/RFI suppression filters.

C. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

D. Incandescent Lamp Dimmers:
   1. 120 volt: Control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
   2. 600 watt: Dimmers shall require no derating when ganged with other devices.

E. 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.

2.4 LIGHTING CONTACTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Square D
   2. Siemens
   3. General Electric

B. Description: Electrically operated and electrically held.

   1. Current Rating for Switching: Listing or rating consistent with type of load served, 30-amp minimum, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion 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 control power transformer, red pilot light and H-O-A switch matching the NEMA type specified for the enclosure.
2.5 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 SENSOR INSTALLATION

A. 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.

3.2 DIMMER INSTALLATION

A. Install dimmers within terms of their listing.

B. Install unshared neutral conductors on line and load side of dimmers according to manufacturer's device listing conditions in the written instructions.

3.3 WIRING INSTALLATION


B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to 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.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Section 260533, "Identification." Provide phenolic nameplate on the cover of each lighting contactor enclosure that identifies the circuits controlled and areas served.
3.5  COMMISSIONING OF LIGHTING CONTROL DEVICES

A. All lighting controls shall be commissioned to ensure they operate according to the manufacturer's specifications. Prior to commissioning, conduct a precommissioning meeting with the Owner and the Engineer to establish the settings for the devices. Provide a commissioning report that provides the following for each room:

1. Lighting control device type and part number.
2. Device settings.

B. Confirmation that devices operate according to the specifications.

3.6  INSTALLED SPARE DEVICES

A. Provide the following spare occupancy sensors including associated raceways and wiring:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dual Technology</td>
<td>6</td>
</tr>
<tr>
<td>Occupancy Sensor Switches</td>
<td>4</td>
</tr>
<tr>
<td>Timer Switches</td>
<td>1</td>
</tr>
</tbody>
</table>

B. Spare devices shall include 75 feet of conduit, faceplates, all require wire, cutting, patching and painting for a complete installation. Location of these units is to be determined by the Owner's representative at the site. The Contractor shall assume that these devices will be installed after all other work is completed. Installation shall occur on an accelerated (night/weekend) schedule. Unused devices are to be turned over to the Owner.

END OF SECTION 260923
SECTION 262413 - SWITCHBOARDS

PART 1 – GENERAL

1.1 SCOPE

A. Provide a new main service switchboard as shown on the drawings and the specification herein.

1.2 SERVICE VOLTAGE

A. As shown on the drawings.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. General Electric, Square D, Eaton or Siemens. Catalog numbers refer to Square D equipment to establish minimum standards per quality and performance.

2.2 MAIN SERVICE SWITCHBOARD

A. Construction: Shall be in accordance with NEMA Class II Construction and arranged for dead front indoor installation consisting of free-standing sections 90 inches high, fully barriered with vertical insulated barrier extending full depth of switchboard. Provide horizontal barrier between protective devices and the metering C.T. compartment. All sections shall align. Entire assembly is to be mounted on a 4" concrete pad. All bolts used to join current-carrying parts shall be installed from the front only to make servicing possible without rear or side access. All top, side and front coverplates shall be field removable. Bussing shall be copper. Switchboard bracing shall be as shown on the drawings.

B. The switchboard shall be fully bussed allowing full use and expansion for future circuit breaker installation.

C. Switch board shall have A-B-C type bus arrangement, left-to-right, top-to-bottom, and front-to-rear, as viewed from the front, shall be used throughout.

D. Ground Bus: Provide continuous and separate neutral and ground busses. Connect to main service ground. Bond each section of switchboard to equipment ground bus.

E. Main and Feeder Protective Devices: Shall be fixed mounted thermal magnetic type molded case circuit breakers with a minimum interrupting ratings as shown on drawings. The main circuit breaker shall be provided with ground fault protection.

F. Voltmeter: Shall be provided. Meter shall read the phase-to-phase and phase-to-neutral voltage on all three phases.
G. Ammeter: Shall be provided, same type as voltmeter, complete with three-current transformers.

H. Instrument Transfer Switches: Provide for ammeter and voltmeters.

I. Potential Transformer: Provide three 120:24V single-phase potential transformers on the main bus (Phase A, B & C). Wire secondary to a terminal strip for use by the building controls contractor.

J. Current Transformers: Provide three current transformers with a 4-20 milliamp output on the main bus (Phase A, B & C). Wire secondaries to a terminal strip for use by the building controls contractor.

2.3 METERING

A. Meters monitoring the whole panel shall be integral to the panel, Square D Powerlogic PM820 or equal. Meter shall have an RS-485 Modbus output.

B. Meters monitoring panel feeders shall be stand-alone type in its own enclosure, Square D Powerlogic E4800 or equal. Meter shall have capacity to separately monitor seven or more individual feeders. Meter shall have an RS-485 Modbus output for each monitored load. Meter shall include current transformers, terminal blocks, and other parts required for the metering function.

C. Meters shall monitor the following values:
   1. Line-to-neutral voltage for all phases
   2. Line-to-neutral average voltage
   3. Line-to-line voltage for all phases
   4. Line-to-line average voltage
   5. Current on each phase
   6. Average current
   7. Neutral current
   8. kVA, kW for all phases, kWh for all phases
   9. kW Demand
   10. kVAR, kVARh for all phases
   11. Power Factor
   12. Thd
   13. Frequency

D. Instantaneous values for these parameters shall be accessible via local indications, and through the remote I/O link, equipped with smart communications card.

PART 3 – EXECUTION

3.1 GENERAL

A. Install all equipment in conformance with manufacture's recommendations.
B. Provide conduit and cabling to connect pulsed meter output to existing EMS System.

3.2 HOUSEKEEPING PADS

A. Install switchgear, main service switchboard and distribution switchboards on 4” housekeeping pads. Equipment shall be level and plumb on all sides, grouted and securely bolted to the floor. Extend equipment grounding to cold water main and ground rods as required by the Code. Verify proper operation of each circuit protective device.

3.3 EQUIPMENT ANCHORAGE

A. All floor mounted equipment shall be securely anchored to slabs.

END OF SECTION 262413
SECTION 262416 - PANELBOARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE
   A. Provide all panelboard equipment as shown on the drawings and specified herein.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS
   A. General Electric, Square D, Siemens, Eaton.

2.2 DISTRIBUTION PANELS
   A. 120/208 volt and 277/480 volt, 3 phase, 4 wire. Provide bolt-on circuit breakers and spaces as indicated on the drawings. Circuit breakers shall have a minimum interrupting rating of 22,000 amperes symmetrical.

2.3 277/480-VOLT PANELS
   A. 277/480-volt, 3-phase, 4-wire. Provide bolt-on circuit breakers and spaces as indicated on the drawings. Minimum cabinet size: 20 inches wide x 5-3/4 inches deep. Circuit breakers shall have a minimum interrupting rating of 14,000 amperes symmetrical.

2.4 120/208-VOLT PANELS
   A. 120/208-volt, 3-phase, 4-wire. Provide bolt-on circuit breakers and spaces as indicated on the drawings. Minimum cabinet size: 20 inches wide x 5-3/4 inches deep. Circuit breakers shall have a minimum interrupting rating of 10,000 amperes symmetrical.

2.5 BUSSING
   A. Panelboard bussing shall be copper or aluminum.
2.6 SPACE FOR FUTURE CIRCUIT BREAKERS OR FUSED SWITCHES

   A. Provide as indicated on the drawings. Spaces shall be completely equipped for the future addition of a circuit breaker or fused switch, including all mounting hardware and buss connections. Unless otherwise noted, spaces shall be sized to accommodate the following future circuit breaker or fused switch:

<table>
<thead>
<tr>
<th>Panel Rating</th>
<th>Minimum Space Ampacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 amps</td>
<td>70 Amps</td>
</tr>
<tr>
<td>225 Amps</td>
<td>125 Amps</td>
</tr>
<tr>
<td>400 Amps</td>
<td>250 Amps</td>
</tr>
<tr>
<td>600 Amps</td>
<td>400 Amps</td>
</tr>
<tr>
<td>800 Amps</td>
<td>600 Amps</td>
</tr>
<tr>
<td>1200 Amps</td>
<td>800 Amps</td>
</tr>
</tbody>
</table>

2.7 MULTIPLE-POLE BREAKERS

   A. Shall have common trip with single handle.

2.8 BREAKER LOCK-OFF DEVICES

   A. Lock-off device shall mount on breaker handle to allow pad locking breaker in off position. Provide for breakers noted on drawings.

2.9 PANELBOARD CIRCUIT NUMBERING

   A. Odd numbers on left side of panel, even numbers on right.

2.10 IDENTIFICATION

   A. Provide nameplates to identify all cabinets and index cards to identify each circuit in the panelboards.

   B. Label all conductors in panels with circuit number adjacent to the circuit breaker. Utilize plastic sleeve markers. T&B SM series or equal.

   C. Panel designations shall be laminated phenolic plastic with white letters. Provide black background for normal service panelboards and red background for panelboards automatically served by the emergency generator. Refer to Section 260553 “Identification.”

   D. Circuit indexes shall be typewritten and identify locations using the final room numbers established by the Owner, not the room numbers shown on the Architect's floor plan. Indexes are to be located on the inside of each panel door in the space provided. Include a copy of all indexes in the Operations and Maintenance Manual.
2.11 GROUND BUS

A. Provide one in each panelboard for terminating branch circuit ground conductors and feeder ground conductors. Multiple ground busses utilizing panelboard enclosures for continuity will not be accepted. Burnish area where ground connection is made to panelboard enclosure.

2.12 SPACE ONLY

A. Means that complete provisions have been made so that only the adding and connection of the circuit breaker will complete the installation.

2.13 CABINETS

A. All panelboards shall be provided with standard hinged door construction.

B. Size of cabinets shall be in accordance with National Electrical Code, minimum size 20 inches wide x 5-3/4 inches deep, or as sized on drawings, sufficiently large to accommodate all equipment and conduit entering the top and bottom. No conduit shall enter sides or back.

C. Cabinet fronts in finished areas shall be flush type, with smooth face and concealed trim clamps and hinges. Finish shall be ANSI 61 light gray. There shall be no monograms or trademarks visible on the face of the cabinet.

D. Cabinet doors shall be tight closing without play when latched. Cabinet doors shall have flush retractable latch mechanisms. All cabinets shall be keyed alike.

2.14 METERING

A. Meters monitoring the whole panel shall be integral to the panel, Square D Powerlogic PM820 or equal. Meter shall have an RS-485 Modbus output.

B. Meters monitoring panel feeders shall be stand-alone type in its own enclosure, Square D Powerlogic E4800 or equal. Meter shall have capacity to separately monitor seven or more individual feeders. Meter shall have an RS-485 Modbus output for each monitored load. Meter shall include current transformers, terminal blocks, and other parts required for the metering function.

C. Meters shall monitor the following values:

1. Line-to-neutral voltage for all phases
2. Line-to-neutral average voltage
3. Line-to-line voltage for all phases
4. Line-to-line average voltage
5. Current on each phase
6. Average current
7. Neutral current
8. kVA, kW for all phases, kWh for all phases
9. kW Demand
10. kVAR, kVARh for all phases
11. Power Factor
12. Thd
13. Frequency

D. Instantaneous values for these parameters shall be accessible via local indications, and through the remote I/O link, equipped with smart communications card.

PART 3 – EXECUTION

3.1 MOUNTING

A. Where panelboards are to be installed against plasterboard walls, provide separate support channels secured to blocking between steel studs. Coordinate blocking work with the Gypsum Wallboard Contractor. Panels shall not be secured directly to gypsum wallboard material. Unless noted otherwise, mount top of panel at 6' 0" above finished floor.

3.2 CLEAN-UP

A. After construction is complete, vacuum the interior of all new and existing panel enclosures and provide touch-up paint on factory finished surfaces.

3.3 SPARE CONDUIT

A. Provide six ¾" spare conduits stubbed into ceiling space from each flush-mounted panelboard.

3.4 TESTING

A. After all wiring is complete, all feeder and branch circuit terminations shall be checked with a torque wrench. Torque levels shall be in accordance with NETA Standard ATS unless otherwise specified by the Manufacturer. A test report which gives the following information for each panelboard shall be submitted to the Engineer two weeks prior to final inspection:

1. Size and insulation type of the phase, neutral and ground conductors.
2. Phase-to-Phase and Phase-to-Neutral operating load voltage.
3. Operating load current (each phase, neutral and ground).
4. Phase-to-Phase and Phase-to-Neutral conductor insulation resistance. Test shall be made with a DC "Megger" (500V minimum) type tester. If tests indicate faulty insulation (less than 8 megohms) the conductors shall be replaced and retested.
5. A copy of the test report shall be included in the Commissioning Field Notebook and the Operations and Maintenance Manual.
6. Lace all conductors within panelboards utilizing tie-wraps

END OF SECTION 262416
SECTION 262726 - WIRING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE
   A. Provide all wiring devices complete with device plates shown on the drawings or specified
      within the specifications.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
   A. Bryant, Cooper Wiring Devices, Hubbell, P & S, or Leviton. All part numbers refer to Hubbell
      to establish minimum standards for quality and performance.

2.2 GENERAL
   A. All devices shall be specification grade. Color shall be ivory for normal services and red for all
      services automatically fed from the emergency generator.

2.3 SWITCHES
   C. Locking: 20-ampere, 120/277-volt, Hubbell No. 1221L (1-pole) Series or No. 1223L (3-way)
      series. Provide two keys with each switch. Cover plate shall be stainless steel with on/off
      labels.

2.4 RECEPTACLES
   A. Duplex Receptacles, Specification-Grade: 20-ampere, 125-volt, 2-pole, 3-wire grounding,
      NEMA Type 5-20R Hubbell No. CR53621 (Ivory Color).
   B. Duplex Receptacles originating from emergency panels, Specification-Grade: 20-ampere, 125-
      volts, 3-wire grounding. NEMA Type 5-20R Hubbell No. CR5362R (Red Color).
C. Duplex Receptacles originating from surge protected panels, Specification-Grade: 20-ampere, 125-volts, 3-wire grounding. NEMA Type 5-20R Hubbell No. CR5362GY (Gray Color).

D. Duplex Receptacles, Safety Type, Specification-Grade: Safety-type, specification-grade device, rated at 20-ampere, 125-volt, grounded type, NEMA Type 5-20R; Hubbell No. SG-63 or approved equal. Receptacles must be capable of accepting double bladed plugs without ground pin.

E. Ground Fault Circuit Interrupter (GFCI) Receptacles: Specification grade, weather resistant, 20-ampere, 125-volt, Class A, 5-milliampere sensitivity, standard or feed-through model and as shown on the drawings. Hubbell No. GF 5262 or approved equal.


G. Weatherproof Receptacles: Weather-resistant, GFCI-type receptacle with in-use, weatherproof, low-profile, lockable, diecast metallic alloy cover. Greenfield No. WIUVPS or equal.

H. Special Receptacles: For other special receptacles, see drawings.

I. Cord Caps: Cord caps on all cords shall be plastic insulated type.

2.5 SURFACE RACEWAY ASSEMBLIES

A. Assemblies shall be as manufactured by Wiremold, of type 700, 2000 or 4000 series (including devices) as noted on the drawings. Color shall be ivory.

B. Provide all required mounting hardware, miscellaneous fittings, end caps, etc. as manufactured by Wiremold.

C. One gang device boxes for use with Wiremold 700 product shall be Wiremold part #V5748. Two gang device boxes for use with Wiremold 700 product shall be Wiremold part #V5748-2.

D. One gang device boxes for use with Wiremold 2000 product shall be Wiremold part #V2048. Two gang device boxes for use with Wiremold 2000 product shall be Wiremold part #V2048-2.

E. One gang device boxes for use with Wiremold 4000 product shall be Wiremold part #V4007C-1. One gang GFCI receptacle mounting cover for Wiremold 4000 product shall be Wiremold part #V4007C-1R.

2.6 VERTICAL MULTI-OUTLETS

A. Free-standing multi-outlet assemblies shall be Walkerduct#5PA 10-4, equipped with single grounded type receptacles.

B. Each unit shall be equipped with T-bar hangers, carpet or tile pad as required, power fed junction box, and ceiling trim plate.

C. All receptacles shall be pre-wired (with ground wire) to power fed junction box.
D. Length of each unit shall be selected to match ceiling height.

E. Color of unit shall be ivory.

F. Acceptable Manufacturers

G. Wiremold equipment which is the approved equal of the equipment specified above is considered acceptable.

H. Substitutions may be considered only when submitted in conformance with Section 260500 “Common Work Results.”

2.7 DEVICE PLATES

A. Prohibited materials

B. Sectional plates shall not be utilized.

C. All devices shall be equipped with stainless steel 0.04” thick with #302 satin finish, except for audiovisual devices which may be plastic.

D. All junction boxes in finished areas shall be provided with stainless steel plates.

2.8 INSTALLATION

A. Install two or more wiring devices shown in one location under a common plate except when outlets are of a different voltages such as telephone and duplex receptacles. Install plates with all edges in continuous contact with finished wall surfaces. Install plates vertically with alignment tolerance of 1/16 inch. Sectional plates are not permitted. No more than one device shall be installed in a single-gang position.

B. Wiring: Branch circuit conductors shall be terminated either in side of or in back of specification-grade devices with screw clamped terminations. Spring-type pressure connections not approved. Wiring devices are not to be used for maintaining circuit continuity. Wiring devices are not to be used for maintaining circuit continuity. Removal of wiring device shall not effect downstream devices.

C. Barrel type key switch shall be used to control lighting in corridors, gyms, cafeterias and restrooms (not required for single occupant restrooms).

D. Orient receptacles so that ground pin is at bottom or to the right.

E. Outlet height to meet ADA requirements or 16 inches minimum above floor.

F. Attach surface raceway assemblies to wall surface by method recommended by manufacturer for the particular wall construction. Use anchos similar to Powers Poly-toggle, catalog #2305 with 1-1/2” screw minimum.
G. Wiremold raceway shall be ivory factory color and shall not be painted. Any raceway attached to the Wiremold product in an unconcealed area which does not come pre-painted from the manufacturer shall properly be prepared for painting and shall be Wiremold #IWE-S ivory spray enamel.

PART 3 – EXECUTION (NOT USED)

END OF SECTION 262726
SECTION 262813 - FUSES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
   A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE
   A. Provide all fuses shown on drawings and specified herein including spare fuses mounted in a fuse cabinet.

1.3 DESCRIPTION
   A. Provide fuses as indicated on the drawings, sized per NEC, and as required for a fully operational system.
   B. All fuses shall be of the same manufacture.
   C. All fuses shall be installed by the Electrical Contractor at jobsite and only when equipment is to be energized. Fuses shall not be installed during shipment.
   D. Spare Fuse Cabinet: Provide a surface mounted spare fuse cabinet with locking door and shelves. Install within the Main Electrical Room. Provide three spare fuses of each type used on the project.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
   A. Bussman, Ferraz Shawmut or Littlefuse.

2.2 FUSES
   A. Provide 200,000 AIC, current limiting, UL, time delay fuses.
   B. Feeders 601-6000 Amps: Class L, KRP-C Time Delay.
   C. Feeders 600 Amps and Less:
      1. Class RK-1, LPN-RK for 250-volt, dual element
      2. Class RK-1, LPS-RK for 600-volt, dual element.
D. For motor circuit 600 volts and below: Class RK-1 or Class J sized at 125% FLC of motor.

2.3 FUSE CABINETS

A. Fuse cabinet shall be of same type and finish as panelboards.

B. Cabinets shall be sized as required to contain spare fuses. Arrange so fuses are stored on adjustable steel shelves with end of fuse carton exposed when door is open.

C. Cabinet shall have provisions for installation of directory card of size required to display information described below. Card shall be behind glass cover.

PART 3 – EXECUTION

3.1 SPARE FUSES

A. At the completion of the project, provide (3) spare fuses of each different type and size used on the project. Any spare fuses utilized during testing must be replaced in order to leave the Owner with the proper amount of spare fuses at completion of the project.

B. Install fuses in fuse holder with fuse rating visible

C. Provide typewritten directory card indicating all fusible devices, together with associated fuse size and type.

END OF SECTION 262813
SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary
Conditions and other Division 01 specification sections, apply to this section.

1.2 SUBMITTALS

A. Product Data: Submit for each type of enclosed switch, circuit breaker and accessory being
provided.

1.3 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other
construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required
workspace clearances and required clearances for equipment access doors and panels.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

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

1. Square D
2. General Electric
3. Siemens
4. Eaton

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

A. Fusible Switch-600A and Smaller: NEMA KS 1, Type HD with clips or bolt pads to
accommodate specified fuses, lockable handle with capability to accept two padlocks, and
interlocked with cover in closed position.

B. Nonfusible Switch-600A and Smaller: NEMA KS 1, Type HD, lockable handle with capability
to accept two padlocks, and interlocked with cover in closed position.
2.3 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Molded-Case Circuit Breaker: NEMA AB 1 with interrupting capacity to meet available fault currents. Provide with the following features and accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

B. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating. Provide with the following features and accessories:

1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.

2.4 ENCLOSURES

A. Rated for environmental conditions at installed locations.

1. Outdoor, wet or damp locations; NEMA 250, Type 3R.
3. Other wet or damp indoor locations; NEMA 250, Type 4.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Control Equipment Mounted to Walls: Mount adjacent units at uniform height. Bolt units to wall or mount on lightweight structural-steel channels bolted to wall. Provide freestanding racks complying with Section 260529 "Hangers and Supports," for controllers not located on walls.

B. Floor-Mounted Control Equipment: Anchor to concrete base.

C. Install fuses in each fusible switch.

3.2 IDENTIFICATION DEVICES

A. Label each switch and circuit breaker on engraved laminated plastic as specified in Section 260553 "Identification."
3.3 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.4 TESTING

A. After all wiring to each unit is complete, the Electrical Contractor shall cooperate with the Mechanical Contractor in testing equipment for proper operation and correct wiring as required for proper operation. All connections shall be checked with a torque wrench. Torque levels shall be in accordance with NETA Standard ATS unless otherwise specified by the manufacturer. A test report which gives the following information for each motor shall be submitted to the Engineer two weeks prior to final inspection:

1. All nameplate data (voltage, phase, full-load current, locked motor current, NEMA design, code letter, RPM, etc.)
2. Measured no-load voltage at motor terminals (all phases)
3. Measured full-load voltage at motor terminals (all phases)
4. Full load operating current (all phases)
5. Motor starter manufacturer and overload heater number (attach the manufacturer's table of overload heater numbers and corresponding motor nameplate ranges)
6. Fuse size and type
7. Motor phase-to-phase and phase-to-ground winding resistance (motors five-HP and larger)

B. A copy of the test report shall be included in the Operations and Maintenance Manuals.

END OF SECTION 262816
SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 MOTOR CONTROLS AND EQUIPMENT CONNECTIONS

A. Scope: Provide all line voltage wiring and connections to equipment and motors as shown on the plans, diagrams or specified herein. Prior to rough-in Contractor shall obtain all necessary electrical and physical information from the trade providing the equipment and adjust installation requirements as necessary for a complete and operable system.

B. Motor Controls, Separately Mounted: Provide separately mounted motor starting equipment as shown or noted. Coordinate location and interlocking with Temperature Controls Contractor. Verify motor horsepower size or full-load amperage prior to ordering overload heaters, and size units in accordance with the National Electrical Code.

1.2 OWNER-FURNISHED EQUIPMENT

A. Provide complete electrical service and connection to all Owner-furnished equipment as shown on the drawings or herein specified, unless indicated otherwise.

1.3 ELEVATOR WIRING

A. Scope: Provide all line voltage wiring and automatic disconnecting means to elevator equipment as shown on the drawings and as specified herein.

B. Pit Lighting and Power: Provide light fixture, receptacle and light switch in pit as shown on the drawings.

C. Elevator Disconnect: Provide surface-mounted elevator fused disconnect switch with shunt-trip located as shown on the drawings.

1.4 KITCHEN WIRING

A. Scope: Provide all wiring for kitchen equipment; connect all equipment; assist the Food Service Equipment Contractor in the testing of equipment after connection.

B. Coordination: The Electrical Contractor shall coordinate with the Food Service Equipment Contractor to ensure that each item of equipment which requires electrical service is properly connected and wired.

C. Equipment Wiring: In general, the Food Service Equipment Contractor shall furnish electrical devices and control equipment which are an integral part of the kitchen equipment and will connect all such equipment wiring brought to a single connection point. Electrical control equipment, which is not an integral part of the equipment, will be furnished by the Food Service Equipment Contractor to the Electrical Contractor for mounting and connection, except as noted.
on drawings. The Electrical Contractor shall provide service connections to each item of equipment; shall mount and connect all control equipment not an integral part of the equipment. The location and method of wiring of control devices shall be ascertained prior to installation.

D. Conduit Roughing-In: Suit the equipment finally approved for installation and conform to the latest approved shop drawings. All wall-mounted devices shall be flush type.

E. Exposed Work: All exposed conduits, enclosures and fittings shall be galvanized except for watertight flexible conduit connections.

F. Connections from Floor: Provide 6’ long galvanized rigid conduit screwed into a flush coupling with watertight flexible conduit connection from coupling to the connection point on each piece of equipment. Provide finish type chrome plated escutcheon ring a floor. All connections at floor shall be watertight.

G. Connections from Wall: Watertight flexible conduit between stainless steel cover plate on outlet box and piece of equipment.

H. Disconnect Switches: Provide for each piece of equipment as required by code. Disconnect switches shall be placed wherever possible within the equipment at the point of connection. Where this is not practical, the location of the disconnect shall be verified with the Architect. Disconnects shall be molded case circuit breaker. Where mounted on the wall, they shall be flush with chrome plated face plate.

I. Hood lights: Furnished with hood. Provide conduits connection to the hood light connection point.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Motor starters shall be GE, Square D, Eaton or Siemens.

2.2 MOTOR CONTROLS

A. Unless noted otherwise, all starters shall include Phase loss and phase unbalance protection.

B. Manual Starters: Toggle type, with overload protection, NEMA 1 enclosure. Square D Class 2510.

C. Magnetic Starters: Full voltage, non-reversing, or multi-speed where shown, NEMA 1 (minimum), 3-leg overload protection, 120-volt control, transformer, hand-off-auto switch, red and green indicating lights, 2-N.O. and 2-N.C. auxiliary contacts, Square D Class 8536 Series. Motors 5 HP and larger provide a phase failure/undervoltage relay.

D. Combination Starters: Full voltage, non-reversing as specified above with integral fused disconnect.

E. Variable Frequency Drives
1. Motor starters shall be ABB. Substitutions may be considered when submitted in conformance with Section 260500 “Common Work Results.”
2. See Division 23 for complete requirements.

F. Provide all required relays, wiring, and miscellaneous equipment for Fire Alarm Fan Shutdown compliant with applicable fire codes in conjunction with the site’s Energy Management System (EMS). Interconnecting controls shall be rated to match starter control voltage.

PART 3 - EXECUTION

3.1 INSTALLATION:
   
   A. Provide shutdown for HVAC equipment through the site’s EMS system.

3.2 ISOLATION
   
   A. All rotating and air handling equipment shall be connected with flexible conduit to provide sound and vibration isolation.

3.3 TESTING
   
   A. After all wiring to each unit is complete, Electrical Contractor shall cooperate with Mechanical Contractor in testing equipment for proper operation and shall correct wiring as required for proper operation. All connections shall be checked with a torque wrench. Torque levels shall be in accordance with NETA Standard ATS unless otherwise specified by the manufacturer. A test report which gives the following information for each motor shall be submitted to the Engineer two weeks prior to final inspection:
      
      1. All nameplate data (voltage, phase, full load current, locked motor current, NEMA design, code letter, RPM, etc.)
      2. Measured no-load voltage at motor terminals (all phases).
      3. Measured full-load voltage at motor terminals (all phases).
      4. Full load operating current (all phases).
      5. Motor starter manufacturer and overload heater number (attach the manufacturer's table of overload heater numbers and corresponding motor nameplate ranges).
      6. Fuse size and type.
      7. Motor phase-to-phase and phase-to-ground winding resistance (motors 5-HP and larger).

   B. A copy of the test report shall be included in the Commissioning Field Notebook and the Operations and Maintenance Manuals.

END OF SECTION 262913
SECTION 265100 - LIGHTING

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 DEFINITIONS
   A. BF: Ballast factor
   B. CRI: Color-rendering index
   C. HID: High-intensity discharge
   D. LER: Luminaire efficacy rating
   E. LED: Light Emitting Diode
   F. Luminaire: Complete lighting luminaire, including lamp and ballast

1.3 SUBMITTALS
   A. Product Data: Submit for each type of luminaire, arranged in order of luminaire designation.
   B. Special Submittals: Provide special submittals as specified on the Luminaire Schedule.
   C. LED/Lamp Data: Provide a list which gives the lamp part number for each luminaire type.
   D. Driver/Ballast Data: Provide a list which gives the ballast part number for each luminaire type.

1.4 COORDINATION
   A. Verify and coordinate the various ceiling system with the light luminaire frame requirements. Provide the proper frame for each luminaire. Luminaires installed in non-accessible ceilings shall be provided with a metal flange.
   B. Verify the voltage of each luminaire. Provide the proper ballast voltage for each luminaire.
   C. The luminaire types indicated on the drawings are intended to show the type of luminaire in that particular room or general area. If a luminaire type designation is missing from a particular luminaire, the Contractor shall assume for purpose of bidding that the luminaire type is the same as adjacent luminaires.
1.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up or testing of equipment. Refer to Section 019113 “General Commissioning” for a list of commissioning activities.

B. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

PART 2 – PRODUCTS

2.1 LUMINAİRES, GENERAL REQUIREMENTS

A. Luminaires Accessories: Provide frames, hangers, spacers, stems, aligner canopies, auxiliary junction boxes and all other hardware as required for a complete installation.

B. UL Labels: Provide UL labels on all luminaires. Luminaires installed in damp or wet locations in interior or exterior areas shall be UL labeled as “Suitable for damp locations,” or “Suitable for wet locations.” Surface-mounted luminaires shall be UL labeled for direct surface mounting.

C. Plastic Diffusers, Covers, and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
   a. Lens Thickness: 0.125-inch minimum unless different thickness is indicated.
   b. UV stabilized.

2. Glass: Annealed crystal glass, unless otherwise indicated.

D. All luminaire hardware and latches shall be steel. Plastic type clips and latches are not allowed.

E. Fire-Rated Enclosures

1. The Electrical Contractor shall provide 5/8” plasterboard minimum, taped box enclosures for all recessed luminaires in 1- or 2-hour fire-rated ceilings, as required by local building or fire codes. Enclosure to provide minimum 3” air space around luminaire. Electrical Contractor to verify with the Architect areas where this provision is applicable.

F. Luminaire Support

1. Hangers for Pendant Industrial Luminaires: Luminaires shall be pendant mounted with rigid stems and swivel canopy unless otherwise specified. Provide seismic restraint wires to adjacent structure to prevent horizontal movement.

2. Safety Hangers: Provide four No. 12 gauge slack wire safety hangers on diagonal corners of each recessed or surface mounted fluorescent luminaire installed on this project. Secure wires to structure above, independent of ceiling system.

G. Luminaire Accessories
1. Luminaire Lenses: All plastic luminaire lenses are to be pattern 12, minimum 1/8-inch thick, and 100 percent virgin acrylic plastic unless specified otherwise. Manufacture: KSH Plastics or approved.

2. Luminaire Hanging and Mounting Accessories: The Electrical Contractor shall provide all necessary hanging or mounting devices for all luminaires and shall be responsible for checking the type needed for various ceiling conditions. Plaster rings shall be provided where required.

3. Exterior Light Luminaires: Unless otherwise noted, exterior light poles shall be 20’ round spun aluminum. Mount on concrete pole bases as shown on drawings.

4. Prewired Splice Boxes: Prewired splice boxes for recessed incandescent or compact fluorescent luminaires shall be 4-inch square or equivalent with a minimum of four 1/2-inch knockouts and shall comply with code-required size for branch circuit wiring.

5. Pre-manufactured Fixture Whips: Fixture whips assembled at the factory may be used to connect recessed light fixtures in accessible ceilings.

H. Proper Lighting Luminaire Types

1. Before ordering lighting luminaires, the Electrical Contractor shall be responsible for verifying and coordinating the ceiling systems and lighting luminaire frame requirements as well as the proper ballast/driver voltage.

2. All luminaire hinged doors to have beveled aluminum frame with regressed lens design unless specified otherwise.

3. Provide 6'-0" long x 3/8-inch flexible conduit pigtail and outlet box for each luminaire where installed in accessible suspended ceilings.

4. The luminaire type symbols indicated on the drawings are intended to show the type of luminaire in that particular room or general area. Each individual lighting luminaire shown on the drawings does not necessarily have a luminaire type symbol shown adjacent to it.

I. Trademark or Monograms

1. There shall be no visible trademarks or monograms on the lighting luminaires.

J. Luminaire Continuity

1. All luminaires of the same general category (i.e., 1x2's, 1x4's, 2x2's, 2x4's, 4x4's) shall be of same manufacture and series to ensure that all lenses and trims match and are compatible in appearance.

K. Locking Clips

1. Electrical Contractor is to provide and install four locking clips per luminaire for all luminaires installed into exposed T-bar ceiling suspension systems. The locking clip are to be attached to the luminaire with a sheet metal screw or similar and secured to the main or supporting T-bar runner to guarantee a secure installation.

L. Surface Mounted Luminaires

1. Provide surface mounted luminaires with UL approval for direct mounting on the various ceilings used. Spacers will not be approved. Where mounted on lay-in ceilings, support luminaires by at least two positive devices which surround the ceiling runner, and which
are supported from the structure above by a No. 12 gauge wire. Spring clips or clamps that connect only to the runner are not acceptable.

2.2 LED LUMINAIRES

A. LED Luminaires shall be in accordance with IES, NFPA, UL, as shown on drawings, and as specified. Where conflicts occur, the most expensive option shall govern, no exceptions.

B. LED Luminaires shall be Reduction of Hazardous Substance (ROHS) – compliant.

C. LED Modules shall include the following features unless otherwise indicated:
   1. Comply with IES LM-79, LM-80, and LM-82 requirements
   2. Color Rendering Index and Color Temperature as specified in Luminaire Schedule
   3. Minimum rated life: 50,000+ hours per IES L70 definition or as specified in Luminaire Schedule
   4. Light Output Lumens as specified in Luminaire Schedule

D. LED downlights: LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling; Housing, LED driver, and LED module shall be products of the same manufacturer.

E. LED Lay In Troffers: LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling; Housing, LED driver, and LED module shall be products of the same manufacturer.

2.3 DRIVERS FOR LED LUMINAIRES

A. LED Drivers: Operation to be at standard rated voltage of driver, not “over-driven”. Comply with UL 1598 and 8750. Test according to IES LM-79 and LM-80.
   1. Minimum efficiency: 85% at full load.
   2. Minimum operation Ambient Temperature: - 20 degrees C (- 4 degrees F)
   3. Input Voltage: 120 – 277 V (+/- 10%) at 60 Hz
   4. Integral short circuit, open circuit, and overload protection
   5. Power Factor: >95%
   6. Total Harmonic Distortion: < 20%
   7. Comply with FCC 47 CFR Part 15

2.4 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. Manufacturer: Sylvania or approved
   1. T8 Lamps: Quicktronic Prostart PSX series with universal voltage.
   2. T5HO Lamps: Quicktronic Prostart T5HO universal, high-ambient temperature with universal voltage.
B. Electronic Ballasts: Comply with ANSI C82.11; programmed-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.

1. Sound Rating: A.
2. Total Harmonic Distortion Rating: Less than 10 percent.
3. Transient Voltage Protection: IEEE C62.41, Category A or better.
4. Operating Frequency: 42 kHz or higher.
5. Lamp Current Crest Factor: 1.7 or less.
6. BF: 0.88 or higher.
7. Power Factor: 0.98 or higher.
8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

C. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 and the following unless otherwise indicated:

1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: 0.98 or higher.

D. Ballasts for Low-Temperature Environments (exterior luminaires whether indicated or not): Temperatures 0-degree F and higher; electronic or electromagnetic type rated for 0-degree F starting and operating temperature with indicated lamp types. Manufacturer Bodine.

E. Ballasts for Dimmer-Controlled Lighting Luminaires: Electronic type.

1. Dimming Range: 100 to one percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

2.5 GENERATOR TRANSFER DEVICE

A. Manufacturer: Bodine

B. Operation

1. The GTD generator transfer device senses the loss of normal power and switches the AC ballast or driver input power connection to an unswitched, generator (or central inverter) supplied lighting circuit. No routine maintenance is required to keep GTD functional; however, like other life safety unit equipment, it should be checked periodically to ensure that it is working properly.
C. UL Listed
   1. The GTD has been tested by Underwriters Laboratories in accordance with the standards set forth in UL 924, “Emergency Lighting and Power Equipment,” and is UL listed for factory or field installation.

D. Specification
   1. Generator (or central inverter) supplied egress lighting shall be provided by using a standard fluorescent or LED luminaire equipped with a Phillips Bodine GTD generator transfer device or approved. The device shall be capable of bypassing the wall switch when the auxiliary generator (or central inverter) powers lighting. The device shall consist of relay switching circuitry and fusing contained in one 8’ x 1.18’ x 1.18’ galvanized steel case, shall operate at 120 or 277 VAC, 60 Hz, shall have all inputs fused to 3 A maximum, shall draw 280 mA and 1.6 watts during normal operation; and shall comply with the current NEC. The device shall be UL listed for installation inside, on top of or remote from the luminaire and shall be warranted for a full five years from date of purchase.

E. Warranty
   1. The GTD generator transfer device is warranted for five (5) full years from date of purchase. This warranty covers only properly installed generator transfer device used under normal conditions. For the warranty period, Phillips Emergency Lighting will, as its option, repair or replace without charge a defective device, provided it is returned to the factory transportation prepaid and our inspection determines it to be defective under terms of the warranty. Repair or replacement, as stated above, shall constitute the purchaser’s exclusive warranty, which does not extend to transportation, installation, labor or any other charges; nor does it apply to any equipment of another manufacturer used in conjunction with the device.

F. Installation
   1. The GTD generator transfer device does not affect normal luminaire operation and comes fully assembled to mount inside, on top of or remote from the luminaire ballast.
   2. In addition to available wiring, the device requires a direct, un-switched connection to a generator (or central inverter) supplied emergency panel and an un-switched source on the same branch circuit as the switched supply.

2.6 FLUORESCENT LAMPS
   A. Manufacturer: Sylvania, GE, Philips, Ushio, as approved.
   B. Low-Mercury Lamps: Comply with EPA's toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.
   C. T8 rapid-start low-mercury lamps, rated 32W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life 20,000 hours, unless otherwise indicated.
D. T8 rapid-start low-mercury lamps, rated 17W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life of 20,000 hours, unless otherwise indicated.

E. T5 rapid-start low-mercury lamps, rated 28W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3000K, and average rated life of 20,000 hours, unless otherwise indicated.

F. T5HO rapid-start, high-output low-mercury lamps, rated 54W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 4100K, and average rated life of 20,000 hours, unless otherwise indicated.

2.7 LIGHTING LUMINAIRE SUPPORT COMPONENTS

A. Comply with Division 26, Section 260529, "Hangers and Supports" for channel- and angle-iron supports and nonmetallic channel and angle supports.


2.8 EXIT SIGNS

A. Internally Lighted Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

B. Provide impact resistant exit signs or shielding for exit signs

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install lamps in each luminaire.

B. Set luminaires level, plumb, and square with ceilings and walls.

C. Support for Luminaires in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling support system rods or wires for each luminaires. Locate not more than six inches from lighting luminaire corners.
2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on luminaires. Wire or rod shall have breaking strength of the weight of luminaire at a safety factor of 3.
D. Suspended Lighting Luminaire Support:
   1. Pendants and Rods: Where longer than 48 inches or when installed adjacent to HVAC duct with diffusers or Duct Sock, brace to limit swinging.
   2. Continuous Rows: Use tubing or stem for wiring at one point, and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.

E. Adjust aimable lighting luminaires to provide required light intensities.

3.2 SPARE LUMINAIRES

A. Provide the following installed spare luminaires:

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit Signs</td>
<td>5%</td>
</tr>
<tr>
<td>Emergency Lighting Units</td>
<td>5%</td>
</tr>
</tbody>
</table>

B. Spare devices shall include 100 feet of conduit and wiring as required for a complete installation. Location of these units to be determined by the Owner's representative at the site. The Contractor shall assume that these luminaires will be installed after all other work is completed. Installation shall occur on an accelerated (night/weekend) schedule. Unused luminaires are to be turned over to the Owner.

3.3 SPARE LAMPS AND BALLASTS

A. Provide the following spare lamps and ballasts/driver (each type):

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamps – fluorescent/HID</td>
<td>5%</td>
</tr>
<tr>
<td>Lamps – LED Module</td>
<td>5%</td>
</tr>
<tr>
<td>Ballasts/Driver (each type)</td>
<td>5%</td>
</tr>
</tbody>
</table>

B. Lamps and ballasts shall be turned over to owner.

3.4 WARRANTY

A. Complete and submit all required forms on behalf of the Owner.

B. Obtain a five-year lamp/ballast warranty certificate and include in the Operations and Maintenance Manual.

END OF SECTION 265100
SECTION 260943 - NETWORK LIGHTING CONTROLS

PART 1 – GENERAL

1.1 SUMMARY

A. The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.

B. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed)

C. All system devices shall be networked together enabling digital communication and shall be individually addressable.

D. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity even if network connectivity to the greater system is lost.

E. The system architecture shall facilitate remote operation via a computer connection.

F. The system shall not require any centrally hardwired switching equipment.

G. The system shall be capable of wireless, wired, or hybrid wireless/wired architectures.

1.2 SUBMITTALS

A. Product Datasheets (general device descriptions, dimensions, wiring details, nomenclature)

B. Riser Diagrams – typical per room type (detailed drawings showing device interconnectivity of devices)

C. Shop Drawings – Plans based on lighting sheets locating any and all devices required for a fully operational lighting control system.

D. Other Diagrams – as needed for special operation or interaction with other system(s)

E. Example Contractor Startup/Commissioning Worksheet – must be completed prior to factory start-up

F. Hardware and Software Operation Manuals

G. Other operational descriptions as needed

1.3 QUALITY ASSURANCE

A. All components and the manufacturing facility where product was manufactured must be ROHS compliant.
B. In high humidity or cold environments, the sensors shall be conformably coated and rated for condensing humidity and -40 degree Fahrenheit (and Celsius) operation.

C. All applicable products must be UL / CUL Listed or other acceptable national testing organization.

1.4 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

B. Coordinate lighting controls with BAS (if necessary) either through IP based intercommunication of system or hardwired auxiliary relay outputs.

C. The installing contractor shall be responsible for a complete and functional system in accordance with all applicable local and national codes.

1.5 WARRANTY

A. All devices in the lighting control system shall have a 5 year manufacturer’s warranty.

B. Warranty period shall begin after the completion of the installation and the system’s start-up and training, the point at which the system owner receives beneficial use of the control system or 1 year after shipment from the manufacturer, whichever occurs first.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer:

1. HBA NX Distributed Intelligence
2. ILC Intelligent Lighting Controls
3. Douglas Lighting Controls
4. nLight Network Control System
5. As approved by the engineer and owner

B. The basis of design product is a distributive lighting control system described throughout this specification and drawings. Other lighting controls system substitutes will be considered as long as they provide similar functionality, are acceptable to the owner, and are submitted as a substitute as described.

C. Substitutions:

1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by the design professional a minimum of 10 working days prior to the bid date
and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.

2. By using pre-approved substitutions, the contractor accepts responsibility and all associated costs for all required modifications to circuitry, devices, and wiring. The contractor shall provide complete engineered shop drawings (including power and control wiring) with deviations from the original design highlighted in an alternate color to the engineer for review and approval prior to rough-in.

2.2 SYSTEM/NETWORK REQUIREMENTS

A. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time based operation.

B. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible so as to minimize overall device count of system.

C. System must interface directly with intelligent LED luminaires such that only CAT-5 cabling is required to interconnect luminaires with control components such as sensors and switches (see Networked LED Luminaire section)

D. Intelligent lighting control devices shall communicate digitally, require <4 mA of current to function (Graphic wall stations excluded), and possess RJ-45 style connectors.

E. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.

F. Devices within a lighting control zone shall be connected with CAT-5e low voltage cabling in any order.

G. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.

H. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.

I. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, or from the network backbone. Standalone “bus power supplies” shall not be required in all cases.

J. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.
K. System shall have one or more primary wall mounted network control “gateway” devices that are capable of accessing and controlling connected system devices and linking into an Ethernet LAN.

L. System shall use “bridge” devices that route communication and distribute power for up to 8 directly connected lighting zones together for purposes of decreasing system wiring requirements.

M. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.

N. Individual lighting zones shall be capable of being segmented into several “local” channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.

O. Devices located in different lighting zones shall be able to communicate occupancy, photocell, and switch information via wired backbone.

P. System shall be capable of operating a lighting control zone according to several sequences of operation. System shall be able to change a spaces sequence of operation according to a time schedule so as to enable customized time-of-day, day-of-week utilization of a space. Note operating modes should be utilized only in manners consistent with local energy codes.

1. Auto-On / Auto-Off (via occupancy sensors)
   a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
   b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
   c. Pressing a switch will turn lights off. The lights will remain off regardless of occupancy until switch is pressed again, restoring the sensor to Automatic On functionality.

2. Manual-On / Auto-Off (also called Semi-Automatic)
   a. Pushing a switch will turn lights on.
   b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.

   a. Pushing a switch will turn lights on.
   b. After initial lights on, zones with occupancy and/or photocell sensors turn lights on/off according to occupancy/vacancy and/or daylight conditions.
   c. Sequence can be reset via scheduled (ex. daily each morning) events

4. Auto-to-Override On
   a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.

c. Sequence can be reset via scheduled (ex. daily each morning) events

5. Manual-to-Override On

a. Pushing a switch will turn lights on.

b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.


b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.

5. Manual-to-Override On

b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.

c. Sequence can be reset via scheduled (ex. daily each morning) events

6. Auto On / Predictive Off

a. Zones with occupancy sensors automatically turn lights on when occupant is detected.

b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.

c. If switch is pressed, lights turn off and a short “exit timer” begins. After timer expires, sensor scans the room to detect whether occupant is still present. If no occupancy is detected, zone returns to auto-on. If occupancy is detected, lights must be turned on via the switch.

7. Multi-Level Operation (multiple lighting levels per manual button press)

a. Operating mode designed specifically for bi-level applications

b. Enables the user to cycle through the up to four potential on/off lighting states using only a single button.

c. Eliminates user confusion as to which of two buttons controls which load

d. Three different transition sequences are available in order to comply with energy codes or user preference)

e. Mode available as a setting on all devices that have single manual on/off switch.

f. Depending on the sequence selected, every button push steps through relays states according to below table

g. In addition to achieving bi-level lighting control by switching loads with relays, the ability to command dimming outputs to “step” in a sequence that achieves bi-level operation is present.

Q. A taskbar style desktop application shall be available for personal lighting control.

R. An application that runs on “smart” handheld devices (such as an Apple® IPhone®) shall be available for personal lighting control.

S. Control software shall enable logging of system performance data and presenting useful information in a web-based graphical format and downloadable to .CSV files.

T. Control software shall enable integration with a BMS via BACnet IP.

U. System shall provide the option of having pre-terminated plenum rated CAT-5 cabling supplied with hardware.
2.3 INDIVIDUAL DEVICE SPECIFICATIONS

A. Control Module (Gateway)

1. Control module shall be a device that facilitates communication and time-based control of downstream network devices and linking into an Ethernet.
2. Devices shall have a user interface that is capable of wall mounting, powered by low voltage, and have a touch screen.
3. Control device shall have three RJ-45 ports for connection to other backbone devices (bridges) or directly to lighting control devices.
4. Device shall automatically detect all devices downstream of it.
5. Device shall have a standard and astronomical internal time clock.
6. Device shall have one RJ-45 10/100 BaseT Ethernet connection.
7. Device shall have a USB port
8. Each control gateway device shall be capable of linking 1500 devices to the management software.
9. Device shall be capable of using a dedicated or DHCP assigned IP address.

B. Networked System Occupancy Sensors

1. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
2. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
3. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional “dual” technology shall be used.
4. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.
5. All sensing technologies shall be acoustically passive meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
6. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Sensors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.
7. Sensors shall be available with one or two occupancy “poles”, each of which provides a programmable time delay.
8. Sensors shall be available in multiple lens options which are customized for specific applications.
9. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
10. All sensors shall have two RJ-45 ports or capable of utilizing a splitter.
11. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue.

12. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.

13. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.

14. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.

15. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.

16. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.

17. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.

18. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray).

19. Wall switch sensors shall be available with optional raise/lower dimming adjustment controls.

20. Network system shall have sensors that can be embedded into luminaire such that only the lens shows on luminaire face.

21. Embedded sensors shall be capable of both PIR and Dual Technology occupancy detection.

22. Embedded sensors shall have an optional photocell.

23. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.

24. Fixture mount sensors shall be capable of powering themselves via a line power feed.

25. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.

26. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).

27. Embedded sensors shall have an optional photocell and 0-10 VDC dimming output.

C. Networked System Daylight (Photocell and or Dimming) Sensors

1. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.

2. Photocell and dimming sensor’s set-point and deadband shall be automatically calibrated through the sensor’s microprocessor by initiating an “Automatic Set-point Programming” procedure. Min and max dim settings as well as set-point may be manually entered.

3. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).

4. Dimming sensors shall control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of class 2 current (typically 40 or more ballasts).

5. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.
6. Combination units that have all features of on/off photocell and dimming sensors shall also be available.

7. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be capable of being controlled as an “offset” from the primary zone.

8. Line voltage versions of the above described photocell and combination photocell/dimming sensors shall be capable of switching both 120 VAC, 277 VAC, and 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor load. Relays shall be dry contacts.

D. Networked System Power (Relay) Packs

1. Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay(s), shall have an optional 2nd relay, 0-10 VDC dimming output, or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.

2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.

3. All devices shall have two RJ-45 ports.

4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button or remote.

5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.

6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.

7. Power Packs and Power Supplies shall be available that are WiFi enabled.

8. Power (Secondary) Packs shall be available that provide up to 16 Amp switching of all lighting load types.

9. Power (Secondary) Packs shall be available that provide up to 5 Amps switching of all lighting load types as well as 0-10 VDC dimming or fluorescent ballasts/LED drivers.

10. Specific Secondary Packs shall be available that provide up to 5 Amps of switching as well as 0-10 VDC dimming of fluorescent ballasts/LED drivers.

11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).

12. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120/277 VAC magnetic low voltage transformers.

13. Specific Secondary Packs shall be available that provide up to 4 Amps of switching and can dim 120 VAC electronic low voltage transformers.

14. Specific Secondary Packs shall be available that provide up to 5 Amps of switching of dual phase (208/240/480 VAC) lighting loads.
15. Specific Secondary Packs shall be available that require a manual switch signal (via a networked Wall Station) in order to close its relay.
16. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
17. Specific Secondary Packs shall be available that control louver/damper motors for skylights.
18. Specific Secondary Packs shall be available that provide a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.

E. Networked System Relay & Dimming Panels
1. Panel shall incorporate up to 4 normally closed latching relays capable of switching 120/277 VAC or up to 2 Dual Phase relays capable of switching 208/240/480 VAC loads.
2. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
3. Panel shall provide one 0-10VDC dimming output paired with each relay.
4. Panel shall power itself from an integrated 120/277 VAC supply.
5. Panel shall be capable of operating as either two networked devices or as one.
6. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.
7. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connection.

F. Networked Auxiliary Input / Output (I/O) Devices
1. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½” knockout.
2. Devices shall have two RJ-45 ports.
3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current (typically 40 or more ballasts).
5. Specific I/O devices shall have an input that read a 0-10 VDC signal from an external device.
6. Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event, run a local/remote control profile, or raise/lower a dimming output.
7. Specific I/O devices shall sense state of low voltage outdoor photocells.
8. Specific I/O devices shall enable RS-232 communication between lighting control system and Touch Screen based A/V control systems.
9. Specific I/O devices shall sense.

G. Networked System Wall Switches & Dimmers
1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Devices shall be available with zero or one integrated Class 1 switching relay.
3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. All sensors shall have two RJ-45 ports.
5. All devices shall provide toggle switch control. Dimming control and low
temperature/high humidity operation are available options.
6. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
7. Devices with dimming control outputs can control 0-10 VDC dimmable ballasts by
sinking up to 20 mA of current (typically 40 or more ballasts).
8. Devices with capacitive touch buttons shall provide audible user feedback with different
sounds for on/off, raise/lower, start-up, and communication offline.
9. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
10. Devices with mechanical push-buttons shall be made available with custom button
labeling
11. Devices with a single on button shall be capable of selecting all possible lighting
combinations for a bi-level lighting zone such that the user confusion as to which of two
buttons (as is present in multi-button scenarios) controls which load is eliminated.

H. Networked System Graphic Wall Station
1. Device shall have a 3.5” full color touch screen for selecting up to 8 programmable
lighting control presets or acting as up to 16 on/off/dim control switches.
2. Device shall enable configuration of lighting presets, switched, and dimmers via
password protected setup screens.
3. Device shall enable user supplied .jpg screen saver image to be uploaded.
4. Device shall surface mount to single-gang switch box
5. Device shall have a micro-USB style connector for local computer connectivity.
6. Device shall have two RJ-45 ports for communication
7. Device shall have two to four buttons for selecting programmable lighting control
profiles or acting as on/off switches.
8. Device shall recess into single-gang switch box and fit a standard GFI opening.
9. Devices shall provide LED user feedback.
10. Communication and Class 2 low voltage power shall be delivered to each device via
standard CAT-5 low voltage cabling with RJ-45 connectors.
11. All sensors shall have two RJ-45 ports.
12. Device shall be capable of reprogramming other devices in its zone so as to implement
user selected lighting scene.
13. Device shall be capable of selecting a lighting profile be run by the system’s upstream
Gateway so as to implement selected lighting profile across multiple zones (and not just
its local zone).
14. Device shall have LEDs indicating current selection.

I. Communication Bridges
1. Device shall surface mount to a standard 4” x 4” square junction box.
2. Device shall have 8 RJ-45 ports.
3. Device shall be capable of aggregating communication from multiple lighting control
zones for purposes of minimizing backbone wiring requirements back to Control
Gateway.
4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired
power supply or delivered via a CAT-5 cabled connection.
5. Device shall be careful of redistributing power from its local supply and connect lighting
control zones with excess power to lighting control zones with insufficient local power.
This architecture also enables loss of power to a particular area to be less impactful on
network lighting control system.
2.4 LIGHTING CONTROL PROFILES

A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network control gateway device and on the software’s host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.

J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

2.5 MANAGEMENT SOFTWARE

A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software.

B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).

C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.

D. A printable network inventory report shall be available via the software.
E. A printable report detailing all system profiles shall be available via the software.

F. Software shall require all users to login with a User Name and Password.

G. Software shall provide at least three permission levels for users.

H. All sensitive stored information and privileged communication by the software shall be encrypted.

I. All device firmware and system software updates must be available for automatic download and installation via the internet.

J. Software shall be capable of managing systems interconnected via a WAN (wide area network)

2.6 BMS COMPATIBILITY

A. System shall provide a BACnet IP gateway as a downloadable software plug-in to its management software. No additional hardware shall be required.

B. BACnet IP gateway software shall communicate information gathered by networked system to other building management systems.

C. BACnet IP gateway software shall translate and forward lighting relay and other select control commands from BMS system to networked control devices.

2.7 SYSTEM ENERGY ANALYSIS & REPORTING SOFTWARE

A. System shall be capable of reporting lighting system events and performance data back to the management software for display and analysis.

B. Intuitive graphical screens shall be displayed in order to facilitate simple viewing of system energy performance.

C. An “Energy Scorecard” shall be display that shows calculated energy savings in dollars, KWHr, or CO₂.

D. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc).

E. Energy savings data shall be calculated for the system as a whole or for individual zones.

F. A time scaled graph showing all relay transitions shall be presented.

G. A time scaled graph showing a zones occupancy time delay shall be presented

H. A time scaled graph showing the total light level shall be presented.

I. User shall be able to customize the baseline run-time hours for a space.

J. User shall be able to customize up to four time-of-day billing rates and schedules.
K. Data shall be made available via a .CSV file

2.8 START-UP & SUPPORT FEATURES

A. To facilitate start-up, all devices daisy-chained together (using CAT-5) shall automatically be grouped together into a functional lighting control zone.

B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.

C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.

D. All system devices shall be capable of being given user defined names.

E. All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.

F. All sensor devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.

PART 3 – EXECUTION

3.1 INSTALLATION

A. All equipment shall be installed in accordance with manufacturer’s installation instructions and in compliance with all applicable local and national codes and requirements.

B. All wireless devices shall come with MAC address labels. These labels should be affixed to the fixture/device that contains the wireless module and in a log book or on as-builds where the location of the wireless device can be recorded.

C. Provide complete installation of system in accordance with Contract Documents.

D. Provide room by room documentation on the commissioning of the system including by not limited to the following:
   1. Sequence of operations
   2. Device settings
   3. Load parameters
   4. Schedules

3.2 FACTORY COMMISSIONING

A. Upon completion of the installation, the system shall be commissioned by the manufacturer’s factory authorized representative who will verify a complete fully functional system.
B. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.

C. Upon completion of the system commissioning, the factory-authorized technician shall provide the proper training to the owner’s personnel on the adjustment and maintenance of the system.

3.3 PROJECT COMMISSIONING

A. The equipment and systems referenced in this section are to be commissioned per General Commissioning Requirements and Commissioning of Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Identify controlled circuits in lighting contactors.

C. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

D. Label time switches and contactors with a unique designation.

END OF SECTION 260943
SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

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.

B. Comply with all requirements of Division 26.

C. Comply with the following applicable standards and codes:

   2. ANSI/TIA/EIA-568-B.1 and addenda
   3. ANSI/TIA/EIA-568-B.2 and addenda
   4. ANSI/TIA/EIA-568-B.3 and addenda
   5. ANSI/TIA/EIA-569-A and addenda
   6. ANSI/TIA/EIA-606 and addenda
   7. ANSI/TIA/EIA-607 and addenda

D. When conflict exists between local or national codes or regulations, the most stringent codes or regulations shall be followed.

1.2 DEFINITION

A. Telecommunications Spaces:

   1. Equipment Rooms (ER)
   2. Telecommunication Rooms (TR)

B. Cross-connects / Distribution Frames:

   1. Main Cross-Connect / Main Distribution Frame (MC / MDF)
   2. Horizontal Cross-connect / Intermediate Distribution Frame (HC / IDF)

C. Pathway: Conduit, wall rack, cable runway, sleeves, saddle bags, and J-hooks.

D. EMI: Electromagnetic Interference.


1.3 SUMMARY

A. Pathway System:
1. In general, only devices have been shown on the drawings. The Contractor shall provide a complete pathway system.
2. Minimum raceway size shall be 1".
3. Provide metallic raceway from all outlet boxes. This raceway may be stubbed above ceiling except where raceway is required to be provided all the way to the telecommunications rack.
4. Provide metallic raceways for cables in walls, above inaccessible ceilings, exposed, where subject to physical damage, or where subject to potentially high EMI or RFI.
5. Use J-hooks spaced no greater than 5 ft apart for open ceiling cabling between metallic raceway stubbed above ceiling and wall rack system shown in corridors.

1.4 WIRE AND CABLE:

1. Comply with all requirements of Division 26 and other provisions of this section.
2. Unless specified otherwise, all cabling shall be plenum rated.
3. Provide wire and cable for each system according to the manufacturers requirements.
4. Underground cabling shall be UL listed for direct build.

1.5 SUBMITTALS

A. Product Data: Submit for each type of product provided.
B. Shop Drawings:

1. Raceway Riser Diagrams: Provide detailed raceway layout. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
2. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building.
3. Device Identification: Identify each device by its address or identification number.
4. System Wiring Diagrams: Include system diagrams unique to project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
5. Shop drawings shall utilize the final room numbers established by the Owner, not the room and building numbers shown on the architectural floor plans.

1.6 QUALITY ASSURANCE

A. Contractor Qualifications:

1. Possess those licenses/permits required to perform telecommunications installations in the specified jurisdiction.
2. Personnel trained and certified to install products.
3. Provide references of the type of installation provided in this specification.
4. Personnel to be competent in Termination, Splicing, Testing, Trouble Shooting Fiber and Copper Products.
5. Be in business a minimum of 5 years and successfully engaged in the routine installation of structured cabling systems (i.e. voice, data, fiber, video, etc.) of similar size and complexity.

6. Possess current liability insurance certificates.

7. Personnel knowledgeable in local, state, province and national codes, and regulations. All work shall comply with the latest revision of the codes or regulations.

B. Warranty: Materials and workmanship hereinafter specified and furnished shall be fully guaranteed by the vendor for 20 years from acceptance and transfer of title against any defects and shall promptly correct or re-perform (including modifications or additions as necessary) any nonconforming or defective work that may occur during this period as a result of faulty materials or workmanship at no additional cost to the customer.

1. The period of the vendor’s warranty (ies) for any items herein are not exclusive remedies, and the customer has recourse to any warranties of additional scope given by the vendor to the customer and all other remedies available at law or in equity.

2. The vendor shall pass along to the customer any additional warranties offered by the manufacturers, at no additional costs should said warranties extend beyond the 20 year period specified herein.

3. This warranty shall in no manner cover equipment that has been damaged or rendered unserviceable due to negligence, misuse, acts of vandalism, or tampering by the customer or anyone other than employees or agents of the vendor. The vendor’s obligation under its warranty is limited to the cost of repair of the warranted item or replacement thereof, at the vendor’s option. Insurance covering said equipment from damage or loss is to be borne by the vendor until full acceptance of equipment and services.

4. If the vendor procures equipment or materials under the Contract, the vendor shall obtain for the benefit of the customer equipment and materials warranties against defects in materials and workmanship to the extent such warranties are reasonably obtainable.

5. All non-consumable products to have a 20-year guarantee. In order to qualify for the guarantee, the structured cabling system must be installed per the following:

   a. Meet all TIA/EIA commercial building wiring standards.
   b. Use products purchased from authorized distributors.
   c. Products must be installed per manufacturers instructions by a Certified Installer.

C. All Networks shall be installed per applicable standards and manufacturer's guidelines.

D. All manufacturers and part numbers are for performance standards only. Other manufacturers meeting the same performance standards as well as a minimum 20-year warranty will be accepted with prior approval via the formal RFI process.

1.7 COORDINATION

A. Coordinate arrangement, mounting, and support of communications equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.
4. So connecting pathways, cables, wireways, wall rack, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation with mechanical, plumbing, structural, electrical and other disciplines throughout all stages of construction.

PART 2 – PRODUCTS

2.1 GENERAL

A. Comply with all requirements of Division 26.

B. Material purchased for this project are to be turned over to owner upon completion of the project.

2.2 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

B. Only devices and telecommunications racks have been shown on the drawings. The Contractor is responsible for providing a complete pathway system. The shop drawings shall contain a fully-designed pathway system.

C. Cable routes shall not run through areas in which flammable materials may be stored or over or adjacent to boilers, incinerators, hot water lines, or steam lines. Proper distances shall be provided between cable routes and sources of heat, EMI, and RFI. Electromagnetic compatibility must be maintained for the cable system.

D. Cable supports NRTL labeled for support of Category 6A cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, saddle bags, and J-hooks.
4. Properly-rated Velcro straps. Plastic cable ties are not allowed.
5. Shall not be attached to drop ceiling grid.
6. Cables shall not be attached directly to grid wire. Grid wire shall not be wrapped around a cable bundle.
7. Shall not be utilized through areas where EMI and RFI may cause interference or degrade system performance. Electromagnetic compatibility for the supporting system must be maintained throughout.

E. Ladder Cable Runways: Nominally 12 inches wide and a rung spacing of 12 inches.

1. For cabling routing within Equipment Rooms and Telecommunication Rooms to rack mounted termination hardware.
2. Mount and secure to walls and racks so as to provide vertical brace for racks.
3. Shall be black in color.
4. All cable trays and wall racks shall be grounded end-to-end to an approved building ground as described in TIA-942.

F. Conduit and Boxes: Comply with requirements in Section 260533, "Raceway and Boxes."
   1. Flexible metal conduit and PVC conduit and sleeves shall not be used.
   2. LB type fittings are not to be used.
   3. Conduit runs shall follow the most direct route possible with no more than 180 degree bends between pull boxes and contain no continuous sections longer than 100 feet.
   4. Pull boxes must be accessible (after all mechanical systems are in place) and used for runs that exceed 100 feet in length and after every cumulative 180 degree changes in direction. All pull boxes must have the insulated bushing installed before cable is pulled.
   5. When multiple conduits are pulled to one box, the minimum box size should be 24 inches by 24 inches by 6 inches. All conduits must maintain run direction through the pull box (i.e. no changing of direction inside the box). The size of pull boxes is determined by the size of conduit leaving and entering the pull box.
   6. A pull string shall be provided in all conduits. Pull a new pull string separate of cabling.
   7. Conduit must be bonded to ground on one or both ends.
   8. Label all pull and junction boxes.
   9. Device boxes shall be 4” square, deep type.

2.3 FIREFSTOPTING

A. Comply with BICSI TDMM, "Firestopping Systems" Article.
B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

2.4 GROUNDING

A. Comply with requirements in Section 260526 "Grounding and Bonding" for grounding conductors and connectors.
B. Comply with ANSI-J-STD-607-A.

2.5 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.
B. Factory test cables on reels according to TIA/EIA-568-B.1.
C. Factory test UTP cables according to TIA/EIA-568-B.2.
D. Factory test multimode and single mode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
E. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

F. Cable will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

PART 3 – EXECUTION

3.1 GENERAL

A. The Contractor shall review all drawings, details and elevations and coordinate with the architect and mechanical contractor prior to installation.

B. Install systems according to manufacturer's written instructions and shop drawings.

C. Provide all raceways, wiring and ancillary equipment necessary for a complete and operational system.

D. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

F. The contractor shall maintain the owner’s facility in a neat and orderly manner during the installation of the communications cabling system. At the completion of work in each area, the contractor will perform a final cleaning of debris prior to moving the installation crew to the next work area.

G. The contractor shall establish a single point of contact with the General Contractor who will be responsible for reporting progress and updating the owner’s representative with issues that the owner must address to facilitate the cabling system installation. The contractor's point of contact (POC) shall provide weekly written reports detailing progress.

3.2 GROUNDING

A. Comply with ANSI-J-STD-607-A.

B. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

C. Grounding system components shall be installed as described in TIA-942, meet the National Electrical Code (NEC), and comply with all local codes.

D. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
E. Signal Ground Terminal: Locate at each equipment cabinet. Isolate from power system and equipment grounding.

F. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

G. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

H. Connect all Telecommunications Ground Bus Bars (TGB) to the Telecommunications Main Ground Bus Bar (TMGB) through the use of a Telecommunications Bonding Backbone (TBB). The TBB shall be installed independent of the building electrical and building ground per ANSI/TIA/EIA-607-A.

I. All vaults must be grounded back to the TMGB.

3.3 PATHWAYS

A. Cable Runways and Wall Racks: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Section 260533 "Raceway and Boxes" for installation of conduits and wireways.

E. Comply with the material and installation requirements specified in Section 260529 "Hangers and Supports."

F. Provide long-radius elbows for all underground raceways. Install manufactured conduit sweeps and long-radius elbows elsewhere whenever possible.

G. Cable minimum bend radius shall not be exceeded in any pathway, in any transition between pathways, or when branching off of a pathway.

H. Raceway, cable runway, and wall racks, and all other pathways systems shall not exceed a 40 percent fill rate.

I. All cable pathways shall keep cable bundle a minimum of 6 inches off of the ceiling grid system. Ceiling grid shall in no way support any cable or cable pathway.

J. Saddle bags or J-hooks shall be spaced no greater than 5 ft apart for open ceiling cabling. Cables shall be properly supported and not sag between supports. Sag indicates additional supports are required.

K. All cables, whether individual or grouped, shall be supported by an approved pathway system.
L. All cable pathways including saddle bags and J-hooks and the pathways they create shall follow building lines and allow access to cabling from hallway and open area locations. Pathways shall not be placed over other end user offices.

M. Cables pathways may only run parallel with electrical conduits if within cable manufacturer’s recommendations and electromagnetic compatibility can be maintained so that no EMI and RFI may cause interference or degrade system performance.

N. Exposed conduit/surface-mount is not allowed and can only be used with written permission from the project manager.

O. Entire length of cable pathway shall be cleaned by conclusion of project. No debris such as clipped cable ties, junk pull string, wall penetration packaging or pieces or other trash is to be left in the ceiling.

P. Do not install any cabling prior to approval from owner provided field inspector.

3.4 WIRING

A. Do not share raceways with other building wiring systems.

B. Wiring Within Enclosures: Bundle, lace and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and nonpower-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

C. Splices, Taps and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets, and equipment enclosures.

D. Identification of Conductors and Cables: Color code conductors and apply wire markers. Coordinate with shop drawings.

3.5 SLEEVES

A. Interior Penetrations of Nonrated Walls, Floors and Ceilings: Provide EMT sleeves. Seal space between the raceway and the wall or floor using joint sealant appropriate for the size, depth and location of the joint. Comply with requirements in Section 079200 "Joint Sealants."

B. Extend sleeves installed in floors 1 to 3 inches above finished floor level.
3.6 FIRESTOPPING

A. Communications penetrations occur when pathways, cables, wireways, or wall racks penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies. This includes both through (complete penetration) and membrane (through one side of hollow fire rated structure) penetrations.

B. Provide firestopping to all penetrations of fire-rated assemblies to restore original fire-resistance rating of assembly including resistance to flame, heat, vapor, and water stream pressure. When penetrating corridor/chase walls, a minimum of 2 engineered firestop devices are required.

C. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

D. Comply with BICSI TDMM, "Firestopping Systems" Article.

E. Contractor shall install appropriate size and quantity to maintain maximum 40 percent fill.

F. Install approved mechanical fire-rated assemblies for corridor firewalls, Equipment Room and Telecommunication Room penetrations. Install sleeves and seal with appropriate fire materials for penetrations only where mechanical fire-rated assemblies cannot be installed per manufacturer’s requirements.

G. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

H. Sleeves in Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

I. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections to ensure all cables and termination hardware is 100 percent free of defects and meets performance standards under installed conditions. Test cables after termination but not cross-connection.

B. All tests shall indicate the appropriate cable identification number, circuit, or pair number.

C. Test instruments:

2. Unless a more frequent calibration cycle is specified by the manufacturer, an annual calibration cycle is anticipated on all test equipment used for this installation.

3. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. For UTP Category 6 performance tests, use at minimum a Fluke DTX Level IV tester that has been factory-calibrated within the last 12 months. Submit copy of calibration certification. Category 6 cabling systems shall be performance verified using an automated test set capable for testing all specified parameters.

D. Visual Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1

2. Visually confirm Category 6A markings of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

E. UTP Cable Tests:

1. Wire map test showing:
   a. Continuity on all pairs.
   b. Shorts between any two conductors.
   c. Reversed pairs.
   d. Transposed pairs.
   e. Split pairs.
   f. Shield continuity (if applicable)
   g. Grounded conductor
   h. Pass/Fail Result

2. DC loop resistance.

3. Length (physical vs. electrical, and length requirements).
   a. Use TDR type device.
   b. Tested from patch panel to patch panel, block to block, patch panel to outlet, or block to outlet as appropriate.
   c. Length shall conform to maximum distance set forth in ANSI/TIA/EIA-568-B.
   d. Record length of longest pair.

4. Insertion loss.

5. Near-end crosstalk (NEXT) loss.

6. Power sum near-end crosstalk (PSNEXT) loss.

7. Equal-level far-end crosstalk (ELFEXT).

8. Power sum equal-level far-end crosstalk (PSELFEXT).


11. Delay skew
F. Optical Fiber Cable Tests:

1. Link End-to-End Attenuation Tests.
   a. Multimode Fiber link measurements: Test at 850 and 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
   b. Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
   c. Singlemode Fiber link measurement: Test at 1310 and 1550 nm in 1 direction.
   d. Conversion from metric to US Standard measurement shall use 3.2808 as a constant with the result rounded to the next highest whole number.
   e. The adjusted cable attenuation value shall be added to the manufacturers mean loss per mated pair of connectors multiplied by the number of mated pairs under test (the testing for this project measures the loss over the installed cable plus two jumpers which accounts for three mated pairs of connectors - subtract one mated pair for the equipment interface to arrive at a total of two mated pairs under test).
   f. Where concatenated links are installed to complete a circuit between devices, the Contractor shall test each link from end to end to ensure the performance of the system. After the link performance test has been successfully completed, each link shall be concatenated and tested.
   g. The expected results for each cable (or group of cables of the same nominal length) shall be calculated before the start of testing and recorded in a space provided on the Contractor’s test matrix. Any fibers that exceed this value shall be repaired or replaced at no cost to the Owner.

2. Length and Splice loss measured via Optical Time Domain Reflectometer (OTDR) accordance to ANSI/TIA/EIA-455-60 (FOTP-60)
   a. Refer to Tier 2 testing in TIA/TSB-140.

G. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.

1. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

2. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

H. End-to-end cabling will be considered defective if it does not pass tests and inspections.

I. Document Data for each measurement and prepare test and inspection reports. Documentation shall be provided in original electronic format as well as PDF on CD for approval. Also provide printed test results obtained directly from the test equipment. Hand written or excel or word typed test results will not be accepted.
1. The CD shall have separate folders labeled Horizontal and Backbone and then be further segregated in subfolders by test type (i.e. scanner, fiber optic attenuation, OTDR traces, power meter test results, etc.).
2. Test data within each section shall be presented in the sequence listed in the administration records.
3. The test equipment by name, manufacturer, model number and last calibration date shall also be provided at the end of the document.
4. The test document shall detail the test method used and the specific settings of the equipment during the test.
5. The test report shall include the test performed, expected test result and the actual test result achieved.

J. The Pass or Fail condition for the cabling run under test is determined by the results of the required individual tests. In order to achieve an overall Pass condition, the results for each individual test parameter must be a Pass. A test result of a parameter shall be marked with an asterisk (*) when the result is closer to the test limit than the accuracy of the field tester. This shall be considered a Fail test result.

K. Any defect in the cabling system installation including but not limited to cable, connectors, feed-through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100% useable conductors in all installed cables. When repairs and re-tests are performed, the problem found and corrective action taken shall be noted. Only “Pass” results and not Marginal Pass* will be accepted.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling and terminals according to Section 260553 "Identification."

3.9 AS-BUILT SHOP DRAWINGS

A. At the completion of the project, provide a complete set of as-built shop drawings (hard copy and CD) showing the following as-built:

1. Raceway layout
2. Wiring
3. Device locations
4. Device identification numbers

END OF SECTION 270500
SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

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 DEFINITIONS

B. Ladder Cable Runway: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
C. LAN: Local area network

1.3 SUMMARY

A. Section Includes:
   1. Telecommunications mounting elements.
   2. Backboards.
   3. Telecommunications equipment racks and cabinets.
   4. Telecommunications service entrance pathways.
   5. Grounding.
B. Related Sections:
   1. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
   2. Section 271500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.
   3. Section 271500 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.4 SUBMITTALS

A. Product Data: Submit for each type of product provided.

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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.


1.6 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.

2. Adjust arrangements and locations of cross-connects (distribution frames) in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

3. Adjust arrangements and locations of equipment that share space in the equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 – PRODUCTS

2.1 PATHWAYS

A. Comply with requirements in Section 270500 “Common Work Results for Communications”. Basket Cable Trays not allowed within Equipment Rooms (ER) and Telecommunication Rooms (TR).

2.2 BACKBOARDS

A. Backboards: Plywood; non-conductive, fire-retardant treated, and 3/4 by 48 by 96 inches.

2.3 EQUIPMENT FRAMES

1. Equipment Frames shall be 42U TrippLite SR42UBEXP SmartRack or approved.

2.4 POWER STRIPS

A. Provide by owner.

2.5 FIRESTOPPING

A. Comply with requirements in Section 270500 “Common Work Results for Communications”.

February 10, 2019
2.6 GROUNDING

A. Comply with requirements in Section 270500 “Common Work Results for Communications”.

B. Telecommunications Ground Bars:
   1. Connectors: Mechanical type, cast silicon bronze, solderless, compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
   2. Telecommunications Main Ground Bus Bar (TMGB): Copper, minimum 1/4-inch-thick by 4 inches wide and a minimum of 12 inches long with 9/32-inch holes spaced 1-1/8 inches apart.
   3. Telecommunications Ground Bus Bar (TGB): Copper, minimum 1/4-inch-thick by 2 inches wide and a minimum of 12 inches long with 9/32-inch holes spaced 1-1/8 inches apart.
   4. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 volt. Lexan or PVC, impulse tested at 5000 volt.

C. Comply with ANSI-J-STD-607-A.

2.7 LABELING

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 – EXECUTION

3.1 GENERAL

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

C. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 BACKBOARDS

A. Provide plywood backboards on all four walls of each telecommunications room.

B. Install backboards with 96-inch dimension vertical. Bottom of plywood is to be six inches above finished floor. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

C. Paint backboards flat white.
3.3 EQUIPMENT FRAMES

A. All racks shall be placed in manner that allows for a minimum of 3 feet of clearance in front and behind all rack mounted devices.

B. All racks shall be securely attached to the concrete floor using 3/8 inch hardware.

C. All racks shall be grounded to the TGB or TMGB.

D. Cross connecting all Telephone and Data services shall be the responsibility of owner.

3.4 PATHWAYS

A. Comply with requirements in Section 270500 “Common Work Results for Communications”. Basket Cable Trays not allowed within Equipment Rooms (ER) and Telecommunication Rooms (TR).

B. Pathway Installation in Communications Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of the room where multiple sheets of plywood are installed around the perimeter walls.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room from overhead.
   4. Extend conduits entering or leaving building 4 inches above finished floor.
   5. Extend sleeves and conduits between floors 1 to 3 inches above finished floor.
   6. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.5 WIRING

A. All cables in the Equipment Rooms and Telecommunication Rooms shall have a non-coiled slack loop by taking the longest usable route to terminate a 3-foot coiled service loop.

3.6 FIRESTOPPING

A. Comply with requirements in Section 270500 “Common Work Results for Communications”.

3.7 GROUNDING

A. Comply with requirements in Section 270500 “Common Work Results for Communications”.

B. Provide Telecommunications Ground Bus Bar (TGB) in each Telecommunications Room.

C. Locate grounding bus bars to minimize the length of bonding conductors. Fasten to wall allowing at least two-inch clearance behind the grounding bus bar. Connect grounding bus bars with No. 6 AWG stranded copper wire to the nearest electrical panel ground and to the building steel. If located outside the room, use No. 4 AWG stranded copper.
D. Connect telecommunications main grounding bus bar with a minimum No. 4 AWG stranded copper grounding electrode conductor to building main service ground point. This installation and termination shall be performed by a licensed electrical contractor. Label “TMGB - Do not disconnect.”

E. All racks shall be grounded to the TMGB or TGB in the respective room by the telecommunication installer.

3.8 IDENTIFICATION

A. Identify system components, wiring and cabling complying with TIA/EIA-606-A. Comply with requirements in Section 260553 "Identification."

B. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 3 level of administration.

C. Labels shall be preprinted or computer-printed type.

END OF SECTION 271100
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 DEFINITIONS
   B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
   C. EMI: Electromagnetic interference
   D. IDC: Insulation displacement connector
   E. LAN: Local area network
   F. UTP: Unshielded twisted pair

1.3 BACKBONE CABLING DESCRIPTION
   A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection. Install backbone cables as shown on the drawings.
   B. Bridged taps and splitters shall not be used as part of backbone cabling.

1.4 PERFORMANCE REQUIREMENTS
   A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.

1.5 SUBMITTALS
   A. Product Data: Submit for each type of product provided.
   B. Shop Drawings:
1. System Labeling Schedules:
   a. Electronic copy of labeling schedules shall be in software and format selected by Owner.
   b. Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.

2. Cabling administration drawings and printouts.

3. Wiring diagrams to show typical wiring schematics including the following:
   a. Cross-connects
   b. Patch panels

4. Cross-connects and Patch Panels: Detail mounting assemblies, and show elevations and physical relationship between the installed components.

5. Cable Tray Layout: Show cable tray route to scale with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
   a. Vertical and horizontal offsets and transitions.
   b. Clearances for access above and to side of cable trays.
   c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
   d. Load calculations to show dead and live loads as not exceeding manufacturer’s rating for tray and its support elements.

1.6 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with the Owner's telecommunications and LAN equipment and service suppliers.

PART 2 – PRODUCTS

2.1 PATHWAYS

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

2.2 UTP CABLE

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

1. Berk-Tek
2. CommScope
3. Mohawk
4. Belden
5. Superior Essex
B. Description: 100-ohm, 24-AWG minimum, solid conductor, 100-pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 5e.
4. Listed and labeled by an NRTL acceptable to Authorities Having Jurisdiction as complying with UL 444 and NFPA 70 for the following types:

   a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
   b. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.

5. Cables shall be in standard increments to the size of the project (one pair per installed horizontal cable fed from respective telecommunications room).

2.3 UTP CABLE HARDWARE

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

1. CommScope
2. Hubbell
3. Leviton
4. AMP

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category.

C. 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.

D. Cross-Connect Cables: Provided and installed by owner.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables. One jack per field for each four-pair UTP cable indicated. Shall be 1100U PowerSum panel or approved.

F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

2.4 MULTIMODE OPTICAL FIBER RISER CABLE

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

1. Berk-Tek
2. CommScope
3. Mohawk
4. Belden
5. Superior Essex

B. Description: X10G Multimode, 50/125-micrometer laser optimized, 6-strand, nonconductive, tight buffer, optical fiber cable. Riser cable shall be 900-micrometer and mechanically strippable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA/EIA-492AAAA-B for detailed specifications.
4. Listed and labeled by an NRTL acceptable to Authorities Having Jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
   b. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.

5. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
6. Minimum Modal Bandwidth: 2000 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
7. Hybrid cables can be utilized upon prior approval.

C. Jacket:

2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.5 SINGLEMODE OPTICAL FIBER RISER CABLE

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

1. Berk-Tek
2. CommScope
3. Mohawk

B. Description: Singlemode, 8.3/125-micrometer, 4-strand, nonconductive, tight buffer, optical fiber cable. Riser cable shall be 900-micrometer and mechanically strippable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
3. Comply with TIA/EIA-492AAAA-B for detailed specifications.
4. Listed and labeled by an NRTL acceptable to Authorities Having Jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
   b. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.

5. Maximum Attenuation: 1.0 dB/km at 1310 nm; 1.0 dB/km at 1550 nm.
6. Hybrid cables can be utilized upon prior approval.

C. Jacket:

2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.6 OPTICAL FIBER CABLE HARDWARE

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

1. CommScope
2. Corning Cable Systems.
3. Hubbell
4. Mohawk
5. Systemax

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors. One connector per field for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

C. Cable Connecting Hardware:

2. Type LC connectors. Insertion loss not more than 0.75 dB.
   a. Aqua connector color for multimode fibers.
   b. Blue connector color for singlemode fibers.

2.7 FIRESTOPPING

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

2.8 GROUNDING

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

2.9 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Section 260553 "Identification."
2.10 SOURCE QUALITY CONTROL

A. Comply with requirements in Section 270500 “Common Work Results for Communications”.

PART 3 – EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes."
3. Conceal conductors and cables in accessible ceilings, walls and floors where possible.

B. Wiring within Enclosures: Bundle, lace and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 PATHWAYS

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

3.4 CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. MUTOA shall not be used as a cross-connect point.
6. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
   a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
b. Locate consolidation points for UTP at least 49 feet from communications equipment room.

c. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than six inches from cabinets, boxes, fittings, outlets, racks, frames and terminals.

8. Install lacing bars to restrain cables, to prevent straining connections and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

9. Bundle, lace and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.

10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable regardless of whether the cable passes Category 6 testing standards.

11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

12. In the Communications Equipment Room and Telecommunication Rooms, install a 10-foot-long service loop on each end of cable when routed within building.

13. In the Communications Equipment Room, install a 50-foot-long service loop on each end of cable when entering or leaving the building.

14. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:


2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

3. Cable shall be terminated in 19-inch rack mounted 110-style IDC frame kits, which include frame, blocks, bottom trough, horizontal wire troughs, connecting blocks, and designation strips. Frames and bottom troughs shall be constructed of carbon steel. Wiring blocks, connecting blocks and horizontal troughs shall be constructed of polycarbonate molding compound.

4. Wire management frames shall be mounted between adjacent vertical frames to provide wire management of cross-connect wire.

5. Wiring blocks shall be marked black every fifth pair.

6. Connecting block terminals shall be constructed of phosphor bronze, plated with a minimum of 150µin of tin-lead over a 50µin minimum nickel underplate.

7. Combinations of 100-pair frames shall be used as required by the backbone pair counts to be terminated in a given room. Backbone frames shall employ 5-pair connecting blocks on each 25-pair row.

8. Punch-down order should follow traditional USOC color code order for multi-pair telephone cables. All termination blocks must utilize a label holder, all labels shall be machine printed on one side and have laminate protective cover and adhere well to cable or label holder.

D. Optical Fiber Cable Installation:
2. Cable shall be terminated on connecting hardware that is in 19-inch rack mounted enclosures with covers that can be closed. Each enclosure will be labeled and each label will be machine printed with permanent ink.
3. All fiber enclosures will be managed with jumper trays below the enclosure.
4. Pulling tension for OSP single mode fiber optic cable shall not exceed 400 pounds or maximum rating of cable, whichever is lesser.
5. If mechanical assistance is required to pull cable through conduit system then the use of a tension limiting device and a force gauge is required.
6. Fiber Optic cables are to be run inside innerduct that is attached to cable tray, saddle bags, J-hook system, or inside conduits.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of eight inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2kVA: A minimum of five inches.
   b. Electrical Equipment Rating between 2 and 5kVA: A minimum of 12 inches.
   d. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
      e. Electrical Equipment Rating Less Than 2kVA: A minimum of 2-1/2 inches.
      f. Electrical Equipment Rating between 2 and 5kVA: A minimum of six inches.
      g. Electrical Equipment Rating More Than 5kVA: A minimum of 12 inches.
     h. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
        i. Electrical Equipment Rating Less Than 2kVA: No requirement.
        j. Electrical Equipment Rating between 2 and 5kVA: A minimum of three inches.
     l. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
3. Separation between Communications Cables and Fluorescent Fixtures: A minimum of five inches.
3.5 FIRESTOPPING

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

3.6 GROUNDING

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

3.7 IDENTIFICATION

A. Identify system components, wiring and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 “Identification.”
   1. Administration Class: 3.
   2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.

D. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications spaces, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.

F. Cable and Wire Identification:
   1. Label each cable within four inches of each termination and tap, where it is accessible in a cabinet or pull point, or junction outlet box, and elsewhere as indicated.
   2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
   3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
   4. Label each terminal strip and screw terminal in each cabinet, rack or panel.
a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.

b. Label each unit and field within distribution racks and frames.

c. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

5. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A. Cables use flexible vinyl or polyester that flex as cables are bent. Label shall be UV-resistant.

H. Label shall identify cable origination and termination.

3.8 FIELD QUALITY CONTROL

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

END OF SECTION 271300
SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

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 DEFINITIONS


B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference

E. IDC: Insulation displacement connector

F. LAN: Local area network

G. MUTOA: Multiuser telecommunications outlet assembly; a grouping in one location of several telecommunications outlet/connectors.

H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

I. UTP: Unshielded twisted pair

1.3 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the Telecommunications Room and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Splitters shall not be installed as part of the optical fiber cabling.
B. A work area is approximately 100 sq. ft and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

D. Do not pull separate cable for telephone. Telephone connections are included as one of the Category 5e cables at every location.

E. Base Bid is a Category 6 system as described in this section.

1.4 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.

1.5 SUBMITTALS

A. Product Data: Submit for each type of product provided.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:
   a. Cross-connects
   b. Patch panels

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
6. Cable tray layout, showing cable tray route to scale with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
   a. Vertical and horizontal offsets and transitions
   b. Clearances for access above and to side of cable trays
   c. Vertical elevation of cable trays above the floor or bottom of ceiling structure
   d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.
1.6 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

PART 2 – PRODUCTS

2.1 PATHWAYS

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

2.2 UTP CABLE

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

1. Berk-Tek
2. CommScope
3. Mohawk
4. Belden
5. Superior Essex

B. Description: 100-ohm, solid conductor, four-pair UTP, Category 6, covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.

2.3 UTP CABLE HARDWARE

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

1. CommScope
2. Leviton
3. Hubbell
4. Amp

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category.
C. 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.

D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables. One terminal per field for each conductor in assigned cables.

E. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables. One jack per field for each four-pair UTP cable indicated. Cat 6 rated. Shall be 1100U PowerSum panel or approved.

F. Jacks and Jack Assemblies: Modular, Cat 6, eight-position modular receptacle units with integral IDC-type terminals.

2.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1, Cat 6.

B. Workstation Outlets: Four-port-connector assemblies mounted in single faceplate.

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. Snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.

   a. Flush mounting jacks.
   b. Legend: Machine printed in the field using adhesive-tape label. Sequential labeling from left to right, top to bottom.
   c. Sequential labeling of jacks from left to right, top to bottom. Each jack shall be numbered with the same number as attached cable.
   d. Blank inserts/modules shall match faceplate in color.
   e. Category 6 jacks shall match faceplate color. Modules shall accept icon designators.

      1) Black icon indicating a data/PC connection
      2) Blue icon indicating a voice/telephone connection
      3) Yellow icon indicating a voice/telephone connection
   f. BNC coaxial bulkheads shall match faceplate in color.
   g. Shall snap into all outlets and modular patch panels.


C. Outlet Boxes:

1. Boxes shall be 5-inch square manufactured by Randl Industries.
D. Floor boxes and Poke-Thru Devices:
   1. For connection to modular furniture, provide 2-inch pathway for cables.
   2. For plug in at floor locations, provide faceplate and jacks and ensure permits installation of Category 6 cables, quantity 4 per location.
   3. Poke-thru must have the same or higher fire-rating as the floor it penetrates.
   4. Provide metal separation between electrical and telecommunication cables.
   5. Provide all covers, top plates, carpet rings, angle connectors, conduit, jacks, and hinged covers for floor boxes and poke-thrus.

E. Wall Phone Faceplates: mounted per ADA forward reach specifications. Wall phone locations will have only 1 Category 5e cable pulled to each location.

2.5 FIRESTOPPING
   A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

2.6 GROUNDING
   A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

2.7 IDENTIFICATION PRODUCTS
   A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
   B. Comply with requirements in Section 260553 "Identification."
   C. Each and every cable will be uniquely identified and will have the same identification at the jack and telecommunications room or equipment room. Provide labels at approximately 6 inches from termination on each end.
   D. All labels will be computer generated, wrap-around, self-laminating, and will be permanent. No permanent markers are to be used for final labeling.
   E. Owner will provide labeling and numbering format along with port numbers for both work area outlets and telecommunication rooms and equipment rooms.

2.8 SOURCE QUALITY CONTROL
   A. Comply with requirements in Section 270500 “Common Work Results for Communications.”
PART 3 – EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes."
   3. Conceal conductors and cables in accessible ceilings, walls and floors where possible.

B. Wiring within Enclosures: Bundle, lace and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

C. All horizontal cables shall be wired according to T568B pin/pair assignments.

3.2 PATHWAYS

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

3.3 CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   5. MUTOA shall not be used as a cross-connect point.
   6. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
      a. Do not use consolidation point as a cross-connect point, a patch connection, or for direct connection to workstation equipment.
      b. Locate consolidation points for UTP at least 49 feet from communications equipment room.
      c. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than six inches from cabinets, boxes, fittings, outlets, racks, frames and terminals.

8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

9. Bundle, lace and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.

10. Pulling tension above maximum allowable tension for cable being used will result in the cable being deemed damaged.

11. Do not install bruised, kinked, scored, deformed or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable regardless of whether the cable passes Category 5e testing standards.

12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.

13. Install a 10-foot-long service loop on each end of cable in the communications equipment room.

14. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of eight inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Group connecting hardware for cables into separate logical fields.

F. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2kVA: A minimum of five inches.
   b. Electrical Equipment Rating Between 2 and 5kVA: A minimum of 12 inches.
d. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

e. Electrical Equipment Rating Less Than 2kVA: A minimum of 2-1/2 inches.
f. Electrical Equipment Rating Between 2 and 5kVA: A minimum of six inches.
g. Electrical Equipment Rating More Than 5kVA: A minimum of 12 inches.
h. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
i. Electrical Equipment Rating Less Than 2kVA: No requirement.
j. Electrical Equipment Rating Between 2 and 5kVA: A minimum of three inches.

3. Separation between Communications Cables and Electrical Motors and Transformers, 5kVA or HP and Larger: A minimum of 48 inches.

4. Separation between Communications Cables and Fluorescent Fixtures: A minimum of five inches.

3.4 FIRESTOPPING

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

3.5 GROUNDING

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

3.6 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification."

1. Administration Class: 3.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing and management. Use unique alphanumeric designation for each cable and label cable, jacks, connectors and terminals to which it connects with same designation. Cable and asset management software shall reflect final as-built conditions.

C. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. Do not paint over manufacturer's label for fire-resistant plywood.

D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.
E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets; backbone pathways and cables; entrance pathways and cables; terminal hardware and positions, horizontal cables, work areas and workstation terminal positions; grounding buses and pathways; and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings in software and format selected by Owner.

G. Cable and Wire Identification:

1. Label each cable within four inches of each termination and tap where it is accessible in a cabinet, junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
4. Label each terminal strip and screw terminal in each cabinet, rack or panel.
   a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device shown.
   b. Label each unit and field within distribution racks and frames.
   c. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Use a different color for jacks and plugs of each service where similar jacks and plugs are used for both voice and data communication cabling.
5. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color, but still complies with requirements in TIA/EIA-606-A. Cables use flexible vinyl or polyester that flex as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Comply with requirements in Section 270500 “Common Work Results for Communications.”

END OF SECTION 271500
SECTION 280500 - ELECTRICAL REQUIREMENTS FOR INTEGRATED SECURITY SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. This section is a Division 28 Basic Electrical Materials and Methods section, and is part of each Division 28 section.

B. Drawings and General Provisions of contract, including General and Supplementary Conditions and Division 01 Specification sections, apply to work of this section.

1.2 DESCRIPTION OF WORK

A. This section shall indicate the scope of work required by the Division 26 Electrical Contractor to coordinate with the Integrated Security Systems installation. The general term “Integrated Security Systems” shall include Intrusion, Access Control, and Surveillance.

B. The Division 26 contractor shall install all raceway, boxes, low voltage cabling, to the existing security system infrastructure. Division 26 contractor shall coordinate all related work with the Integrated Security Systems contractor.

C. The Integrated Security Systems contractor will be under direct contract to Owner.

1.3 CONTRACTOR INTERFACE AND COORDINATION

A. This installation requires extensive interfacing - It is the sole and exclusive responsibility of this contractor to clarify any questions or discrepancies with the Integrated Security System contractor and the Owner’s representative and to ascertain and verify all installation conditions about which he is unsure prior to commencing work. No additional post bid allowances will be made.

PART 2 – PRODUCTS

2.1 GENERAL

A. Raceway systems including conduit, boxes, cable tray, supporting devices, etc. shall be as specified in other Division 26/27 sections.

B. Backboards shall be furnished and installed by the Electrical Contractor. Backboard shall be 3/4” plywood (AD grade), one side finished smooth, painted with two coats of white fire-retardant paint. Sizes as indicated on the drawings.

C. Cable Supports and Wraps
   a. Approved manufactures are Caddy, B-Line, or equal.
   b. Bridal rings are not approved for use.
   c. J-Hook width shall be minimum 3/4". Provide size appropriate for conductor quantity. Multi-Tier J-Hooks shall be provided to separate different low voltage systems where a common route or pathway is used.
   d. Acceptable alternate product: Caddy #CATCR50 cable retainer

2. Tie-Wrap:
   a. Approved manufactures are Leviton or equal.
   b. Tie-Wraps shall be recloseable loop wrap style. Available in 1/2" wide, 15’-75’ bulk rolls of Hook and Loop Wrap.
   c. Plastic fasteners are not approved for use.

2.2 CABLE

A. Division 26/27 shall furnish and install the following cable types from each device. The following cable is distributed by C.W.C. Inc., Kent, WA, (253) 872-6590. Or equal substitution permitted.

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>CABLE DESCRIPTION</th>
<th>CAT. NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Door Position Switch</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>2. Electromagnetic Door Lock or Strike</td>
<td>6C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P226CS-04</td>
</tr>
<tr>
<td>3. Door Release Pushbutton</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>4. Request-to-Exit Motion Detector</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>5. Access Control Card Reader</td>
<td>6C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P226CS-04</td>
</tr>
<tr>
<td>6. Motion Sensor (Occupancy Sensor)</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>7. Glass Break Detector</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>8. Window Position Switch</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>9. Annunciator</td>
<td>4C #22 OAS Yellow Plenum</td>
<td>Lake Cable # P224CS-04</td>
</tr>
<tr>
<td>10. Siren</td>
<td>2C #18 OAS Yellow Plenum</td>
<td>Lake Cable # P182CS-04</td>
</tr>
<tr>
<td>11. Magnetic Lock</td>
<td>2C #18 OAS Yellow Plenum</td>
<td>Lake Cable # P182CS-04</td>
</tr>
</tbody>
</table>
12. Camera, Indoor, Fixed Position
   (1) 2C #18 OAS Yellow Plenum
        CAT 5E Yellow Plenum
        Lake Cable # P182CS-04
        Coleman # 966956-16-02

13. Camera, Outdoor, Fixed Position
   (2) 2C #18 OAS Yellow Plenum
        CAT 5E Yellow Plenum
        Lake Cable # P182CS-04
        Coleman # 966956-16-02

14. Camera, Indoor and Outdoor, PTZ
   (2) 2C #18 OAS Yellow Plenum
        CAT 5E Yellow Plenum
        Lake Cable # P182CS-04
        Coleman # 966956-16-02

15. Blue Strobe
    2C #18 OAS Yellow Plenum
    Lake Cable # P182CS-04

16. Speaker/Mic
    2C #18 OAS Yellow Plenum
    Lake Cable # P182CS-04

17. Sounder (Pizo)
    2C #18 OAS Yellow Plenum
    Lake Cable # P182CS-04

18. Video Monitor
    RG-59 Shld Coax Yellow Plenum
    Tappan # P20RG59FM/CMP

PART 3 – EXECUTION

3.1 GENERAL INSTALLATION

A. All cables shall be installed as individual home runs from the device to the head-end equipment. No mid-run cable splices will be allowed.

B. Visually inspect all wire and cable for faulty insulation prior to installation.

C. Neatly coil 24” free cable at the device outlet and coil and bundle 20’ of free cable at the head-end equipment.

D. Provide supports as required at 4’-0” intervals minimum. Integrated Security Systems cabling shall be supported separately from other low voltage system wiring. Install multiple J-hooks where to separate various systems where a common routing path is used.

E. Neatly bundle and wrap all horizontally run wire and cable at maximum 5’-0” intervals.

F. All system wiring within vertical riser shafts (if required) shall be bundled, wrapped and tied to the structure at 10’-0” intervals in order to isolate it from other wire and cable within the shaft. Additionally, all wire and cable within the shaft shall be supported at least every two floors using Greenlee Slack Strips (split mesh lace closing) or approved equal. Provide all personnel and equipment necessary to install and support the cable. All wire and supports shall be UL listed for the application.

G. Wire and cables shall be protected from physical damage by ensuring that the bundles are kept off the floor in traffic areas. Care shall be taken to ensure that excess stress is not placed on large bundles of wire and cable at the Head-end. Adequate means shall be provided for fully protecting all materials and equipment against damage from any cause until final acceptance of the work.
H. Provide grommets and strain relief material where necessary to avoid abrasion and tension on the wire and cable.

I. Testing: Wiring shall be completely installed and tested for continuity, short circuits, and ground faults before final connections by the Integrated Security Systems contractor are made. Use approved Megger tester.

J. Labeling: Identify both ends of each wire with room number or location of component to match identification or wiring diagram. Wire markers shall be located adjacent to connection point here easily visible. Marking system shall be Brady IDPro Printer with WML-311-292 labels or approved equal.

K. Mark all cables in common at both ends using a permanent method such as self-laminating write-on cable marking tape. Tags shall be installed when wire and cables are installed. Permanent labels will be installed by the Integrated Security Systems contractor when terminations are made.

L. Bond all systems raceways per Section 260526.

M. Stub conduits from device outlet box to accessible ceiling. Install insulated throat liner or insulated bushing at stub end.

N. Provide wiring and connections for all line voltage equipment panels and power supplies as required by the Integrated Security Systems contractor.

O. Coordinate the routing of low voltage wire and cable to avoid interference from line voltage systems. Separate parallel runs by 12”. Crossing runs shall be separated 6”. Do not allow Class 2 cable to be housed or come into contact with Class 1, power or lighting cable. Observe all requirements of NEC including Article 725 and 760.

P. Sleeves shall be installed at each cable penetration through walls, floors and ceilings. Sleeves shall be minimum 3/4" with insulated inserts. Sleeves shall be installed regardless of wall type construction, fire rated or non-fire rated.

Q. Firestop all conduits that pass through fire rated floors, ceilings and walls. Sealing of openings between floors, through rated fire and smoke walls, existing or created by the contractor for cable pass through shall be the responsibility of the contractor. Sealing material and application of this material shall be accomplished in such a manner that is acceptable to the local fire and building authorities having jurisdiction over this work. Creation of such openings as are necessary for cable passage between locations as shown on the drawings shall be the responsibility of the contractor's work. Any openings created by or for the contractor and left unused shall also be sealed as part of this work.

R. In no instance shall any UL labeled door or frame be drilled, cut, penetrated or modified.

S. Roof penetrations are not allowed unless specifically approved by the architect and shown on the drawings. The cable should be brought in through the wall (with a drip loop) instead of through the roof. In those cases where a roof penetration is absolutely necessary, a 1" conduit should be installed and the cabling run through that. The roof flashing/repair shall be performed by a qualified roofing contractor normally in the business of commercial roofing. Flashing shall be in accordance with NRCA standard practices.
T. Seal all outdoor system components or those subject to water or moisture with neoprene gaskets or silicon sealant. Use a UL listed compound for all watertight seals. Contractor shall ensure that exterior wall penetrations are installed in such a manner as to prevent water seepage.

U. All cutting and patching of new and existing construction required for the installation of systems and equipment shall be the responsibility of this contractor. All cutting shall be accomplished with masonry saws, drills or similar equipment to provide neat uniform openings. Refer to other Division 26/27 specification sections for complete cutting and patching information.

3.2 SUMMARY OF INSTALLATION REQUIREMENTS FOR INTEGRATED SECURITY SYSTEMS

A. Division 26/27/28 shall furnish and install the following:

1. Outlet boxes at each device location: 4”x2-1/8” square box with 1-gang ring.
2. 3/8” flex into door frames for door position switches.
3. Stub out 3/4” conduit from each box to accessible ceiling space.
4. Sleeve all cable penetrations through walls, floors and ceilings.
5. Grounding and bonding.
6. Wire and cable from each device to head-end equipment.
7. Label and tag wire and cables.
8. Test wire and cables for continuity and short-circuit.
10. 3/4” thick communications backboards.
11. Firestopping around conduits that penetrate fire rated floors, ceilings and walls.
12. All 120 VAC power connections.

END OF SECTION 280500
SECTION 311000 - SITE CLEARING

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 the following:
   1. Protecting existing trees, shrubs, groundcovers, plants, grass and other vegetation to remain.
   2. Removing existing trees, shrubs, groundcovers, plants, grass and other vegetation.
   3. Clearing and grubbing.
   4. Stripping and stockpiling topsoil.
   5. Removing above- and below-grade site improvements.
   6. Disconnecting, capping or sealing, and removing site utilities.
   7. Temporary erosion and sedimentation control measures.

B. Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

C. Related Sections include the following:
   1. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.

1.3 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.
1.4 MATERIAL OWNERSHIP

A. Except for materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

B. Record drawings, identifying and accurately locating capped utilities and other subsurface conditions.

1.6 QUALITY ASSURANCE

A. Tree Service Qualifications: An experienced tree service firm that has successfully completed tree protection and trimming work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site on a full-time basis during execution of the Work.

B. Tree Pruning Standards: Comply with ANSI A300, “Tree, Shrub, and Other Woody Plant Management Standard Practices,” unless more stringent requirements are indicated.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Improvements on Adjoining Property: Permission for performing site clearing indicated on property adjoining Owner's property shall be obtained by the Contractor prior to proceeding.

C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.

D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing. Do not commence site clearing operations until utilities have been located.

E. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.
PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving."

1. Obtain approved borrow soil materials off-site when satisfactory soil materials are not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to requirements of authorities having jurisdiction and the sediment and erosion control Drawings.

B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.

1. Do not store construction materials, debris, or excavated material within fenced area.

2. Do not permit vehicles, equipment, or foot traffic within fenced area.

3. Maintain fenced area free of weeds and trash.

B. Do not excavate within tree protection zones, unless otherwise indicated.
C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

1. Cover exposed roots with burlap and water regularly.
2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
3. Coat cut faces of roots more than 1-1/2 inches (38 mm) in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
4. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect and Owner.

1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status, as determined by Architect.

E. Grade Lowering: Where new finish grade is indicated below existing grade around trees, slope grade beyond drip line of trees. Maintain existing grades within drip line of trees.

F. Minor Fill: Where existing grade is 6 inches (150 mm) or less below elevation of finish grade, fill with topsoil. Place topsoil in a single uncompacted layer and hand grade to required finish elevations.

G. Moderate Fill: Where existing grade is more than 6 inches (150 mm), but less than 12 inches (300 mm), below elevation of finish grade, place drainage fill, filter fabric, and topsoil on existing grade as follows:

1. Carefully place drainage fill against tree trunk approximately 2 inches (50 mm) above elevation of finish grade and extend not less than 18 inches (450 mm) from tree trunk on all sides. For balance of area within drip-line perimeter, place drainage fill up to 6 inches (150 mm) below elevation of grade.
2. Place filter fabric with edges overlapping 6 inches (150) minimum.
3. Place fill layer of topsoil to finish grade. Do not compact drainage fill or topsoil. Hand grade to required finish elevations.

3.4 TREE PRUNING

A. Prune remaining trees affected by temporary and new construction.

B. Prune remaining trees to compensate for root loss caused by damaging or cutting root system. Provide subsequent maintenance during Contract period as recommended by a qualified arborist.

C. Pruning Standards: Prune trees according to ANSI A300.
3.5 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
   1. Arrange with utility companies to shut off indicated utilities.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Architect not less than two days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Architect's written permission.

C. Excavate for and remove underground utilities indicated to be removed.

3.6 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction. Removal of trees and shrubs within area of new construction shall include digging out stumps and obstructions and grubbing roots. Removal of trees in areas adjacent to trees that are to remain and be protected shall include tree removal and grinding of stump to 3” below finished grade. Stump and root removal is not allowed in these areas to preserve health of adjacent trees.
   1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
   2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
   3. Completely remove stumps, roots, obstructions, and debris extending to a depth of 18 inches (450 mm) below exposed subgrade.
   4. Use only hand methods for grubbing within tree protection zone.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
   1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches (200 mm), and compact each layer to a density equal to adjacent original ground.

3.7 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
   1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
1. Limit height of topsoil stockpiles to 72 inches (1800 mm).
2. Do not stockpile topsoil within tree protection zones.

3.8 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
   1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
   2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.9 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
   1. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION 311000
SECTION 312000 - EARTH MOVING

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 the following:
   1. Preparing subgrades for slabs-on-grade, walks, pavements, and landscaping.
   2. Excavating and backfilling for buildings and structures.
   3. Drainage course for slabs-on-grade.
   4. Base course for walks and pavements.
   5. Subsurface drainage backfill for walls and trenches.
   6. Excavating and backfilling for underground utilities and buried utility structures.

B. Work and materials shall comply with the requirements and standards of the authorities having
   jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and
   materials shall comply with the most current edition of the Standard Specifications for Road,
   Bridge, and Municipal Construction as jointly promulgated by the Washington State
   Department of Transportation and the Washington State Chapter of the American Public Works
   Association.

C. Related Sections include the following:
   1. Division 31 Section "Site Clearing" for temporary erosion and sedimentation control
      measures, site stripping, grubbing, stockpiling topsoil, and removal of above- and below-
      grade improvements and utilities.

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to
      support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Course placed between the subgrade and walk or pavement.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
E. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. (0.76 cu. m) for bulk excavation or 3/4 cu. yd. (0.57 cu. m) for footing, trench, and pit excavation.

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, manholes, catch basins, drywells, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

J. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below base course, drainage fill, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each on-site and borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 1557 for each on-site and borrow soil material proposed for fill and backfill.
3. Submit certification that the soil materials are acceptable and meet the Project requirements.

C. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.

1.5 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548.
1.6 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

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: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than 3 inches (75 mm) in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Base Course: Crushed rock surfacing used for base course shall conform to WSDOT Standard Specifications section 9-03.9(3), “Top Course”.

E. Structural Fill: Structural fill material shall consist of clean, free-draining sand, or a sand and gravel mixture, each containing not more than 5 percent fines by weight (fines defined as silt and clay sized particles passing the U.S. No. 200 sieve). Structural fill shall be free of debris, organic material, frozen soil, and rock particles greater than 4 inches in diameter. Structural fill shall conform to WSDOT Standard Specifications section 9-03.14(1), “Gravel Borrow”.

F. Drainage Course: Structural fill placed as a capillary break material below slabs shall consist of 1 ½ inch minus clean crushed gravel with negligible sand or fines in conformance with WSDOT Standard Specification section 9-03.1(4)C, “Grading No. 57”.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand in conformance with WSDOT Standard Specification section 9-03.12(3).

H. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.
2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: If not specified on the plans, provide a nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and WSDOT Standard Specification section 9-33, “Construction Geosynthetic”.

B. Separation Geotextile: If not specified on the plans, provide a woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and WSDOT Standard Specification section 9-33, “Construction Geosynthetic”.

2.3 ACCESSORIES

A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:

2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

B. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) 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 (750 mm) deep; colored as follows:

2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

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 earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface as specified in Division 31 Section "Site Clearing."
C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing," during earthwork operations.

D. Protect subgrades and foundation soils against freezing temperatures and frost.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

A. Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). 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 Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

2. Excavation for Underground Tanks, Basins, and Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.
1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

2. Utility trenches shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, utility trenches shall comply with the most current edition of the Standard Specification for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: 12 inches (300 mm) minimum each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

D. Trench Bottoms: Excavate trenches 6 inches (150 mm) deeper than bottom of pipe elevation to allow for bedding course. Hand excavate for bell of pipe.

3.8 SUBGRADE INSPECTION

A. If Geotechnical Testing Agency determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

B. Proof-roll subgrade below the building slabs and pavements to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Testing Agency, and replace with compacted backfill or fill as directed.

C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Geotechnical Testing Agency without additional compensation.

3.9 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.
3.10 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.11 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

D. Place and compact final backfill of satisfactory soil to final subgrade elevation.

E. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.12 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 layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use structural fill.
3. Under steps and ramps, use structural fill.
4. Under building slabs, use structural fill.
5. Under footings and foundations, use structural fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.13 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.

### 3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches (200 mm) in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches (100 mm) 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 (300 mm) of existing subgrade and compact each layer of backfill or fill soil material at 95 percent.
2. Under walkways, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 95 percent.
3. Under lawn or unpaved areas, scarify and recompact top 6 inches (150 mm) below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at 90 percent.

### 3.15 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.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch (25 mm).
2. Walks or Pavements: Plus or minus 1/2 inch (13 mm).

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3-m) straightedge.
3.16 BASE COURSE

A. Place base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place base course under pavements and walks as follows:
   1. Place base course material over subgrade under pavements and walks.
   2. Shape base course to required crown elevations and cross-slope grades.
   3. Place base course 6 inches (150 mm) or less in compacted thickness in a single layer.
   4. Place base course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
   5. Compact base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.17 DRAINAGE COURSE

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 6 inches (150 mm) or less in compacted thickness in a single layer.
   2. Place drainage course that exceeds 6 inches (150 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick.
   3. 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 1557.

3.18 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage and pay for services of a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

C. 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, verified by the geotechnical engineering testing agency.

D. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
1. **Paved and Building Slab Areas:** At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. (186 sq. m) or less of paved area or building slab, but in no case fewer than 3 tests.

2. **Foundation Wall Backfill:** At each compacted backfill layer, at least 1 test for each 100 feet (30 m) or less of wall length, but no fewer than 2 tests.

3. **Trench Backfill:** At each compacted initial and final backfill layer, at least 1 test for each 150 feet (46 m) or less of trench length, but no fewer than 2 tests.

4. **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 to depth required; recompact and retest until specified compaction is obtained.**

### 3.19 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.**

   1. Scarify or remove and replace soil material to depth as directed by geotechnical engineering testing agency; reshape and recompact.

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.

### 3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. **Disposal:** Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 312000
SECTION 321216 - ASPHALT PAVING

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. Hot-mix asphalt patching.
   2. Hot-mix asphalt paving.
   3. Pavement-marking paint.
B. Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.
C. Related Sections:
   1. Division 02 Section "Structure Demolition" for demolition, removal, and recycling of existing asphalt pavements, and for geotextiles that are not embedded within courses of asphalt paving.
   2. Division 31 Section "Earth Moving" for subgrade preparation, grading, and base course.

1.3 DEFINITION
A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.
B. WSDOT: Washington State Department of Transportation.

1.4 SUBMITTALS
A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
   1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
B. Material Certificates: For each paving material, from manufacturer.
C. Material Test Reports: For each paving material, from a qualified testing agency.

D. Field quality-control test reports, from a qualified testing agency.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, or if rain is imminent or expected before time required for adequate cure. Surface and air temperatures shall conform to requirements of WSDOT Standard Specifications.

B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature in conformance with WSDOT Standard Specifications 8-22.

C. Traffic Control: Maintain access for vehicular and pedestrian traffic as required.

PART 2 - PRODUCTS

2.1 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.


2.2 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, in conformance with WSDOT Standard Specifications 9-02.

A. Tack Coat: ASTM D 977 emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application, in conformance with WSDOT Standard Specifications 5-04.3(5)A.

B. Water: Potable.

2.3 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.


C. Paving Geotextile: AASHTO M 288, nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications, in conformance with WSDOT Standard Specifications 9-33.

D. Joint Sealant AASHTO M 324, Type IV, hot-applied, single-component, polymer-modified bituminous sealant, in conformance with WSDOT Standard Specifications 9-04.2.

E. Pavement-Marking Paint: Comply with WSDOT Standard Specifications 9-34.2(3), Low VOC Waterborne Paint.
   1. Color: As indicated.

F. Glass Beads: AASHTO M 247, Type 1, in conformance with WSDOT Standard Specifications 9-34.4.

G. Wheel Stops: Precast, air-entrained concrete, 2500-psi (17.2-MPa) minimum compressive strength, 4-1/2 inches (115 mm) high by 9 inches (225 mm) wide by 72 inches (1800 mm) long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.
   1. Dowels: Galvanized steel, 3/4-inch (19-mm) diameter, 15-inch (381-mm) minimum length.
   2. Adhesive: As recommended by wheel-stop manufacturer for application to pavement.
2.4 MIXES

A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Testing Agency, and replace with compacted backfill or fill as directed.

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

3.2 PATCHING

A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

C. Patching: Fill excavated pavements with hot-mix asphalt for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.3 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 HOT-MIX ASPHALT PLACING

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
3. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet (3 m) wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Transverse Joints: Comply with WSDOT Standard Specification 5-04.3(12)A.
3. Longitudinal Joints: Comply with WSDOT Standard Specification 5-04.3(12)B.
4. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
5. Compact asphalt at joints to a density within 2 percent of specified course density.

3.6 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to specified density.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated. Comply with WSDOT Standard Specification 5-04.

B. Pavement Surface Smoothness: Comply with WSDOT Standard Specification 5-04.3(13).

3.8 PAVEMENT MARKING


3.9 WHEEL STOPS

A. Install wheel stops in bed of adhesive as recommended by manufacturer.

B. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.
3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage and pay for a qualified testing agency to perform tests and inspections and to prepare test reports.

B. Field quality control, testing, and inspections shall comply with WSDOT Standard Specifications.

C. Replace and compact hot-mix asphalt where core tests were taken.

D. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements. Additional testing and inspecting, at Contractor’s expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.11 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

   1. Do not allow milled materials to accumulate on-site.

END OF SECTION 321216
SECTION 321313 - CONCRETE PAVING

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 exterior cement concrete pavement for the following:
   1. Driveways.
   2. Curbs and gutters.
   3. Walkways.

B. Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

C. Related Sections include the following:
   1. Division 03 Section "Cast-in-Place Concrete" for general building applications of concrete.
   2. Division 31 Section "Earth Moving" for subgrade preparation, grading, and base course.

1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

B. WSDOT: Washington State Department of Transportation.

1.4 SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated. Include technical data and tested physical and performance properties.

B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
C. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance with the specified requirements.

D. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

E. Field quality-control test reports, from a qualified testing agency.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.


D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

1.6 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required.

PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

1. Use flexible or curved forms for curves with a radius 100 feet (30.5 m) or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
2.2 STEEL REINFORCEMENT


2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, Type I. Comply with WSDOT Standard Specification 9-01. Supplement with the following:


1. Maximum Coarse-Aggregate Size: 1-1/2 inches (38 mm) nominal.

C. Water: ASTM C 94/C 94M.


E. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material. Comply with WSDOT Standard Specification 9-23.6.

1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
2. Retarding Admixture: ASTM C 494/C 494M, Type B.
3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.

2.4 CURING MATERIALS


B. Absorptive Cover: AASHTO M 182, Class 4, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry. Comply with WSDOT Standard Specification 9-23.5.

D. Water: Potable.


2.5 RELATED MATERIALS


2.6 PAVEMENT MARKINGS


1. Color: As indicated.

B. Glass Beads: AASHTO M 247, Type 1, in conformance with WSDOT Standard Specification 9-34.4.

2.7 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete, 2500-psi (17.2-MPa) minimum compressive strength, 4-1/2 inches (115 mm) high by 9 inches (225 mm) wide by 72 inches (1820 mm) long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 3/4-inch (19-mm) diameter, 15-inch (381-mm) minimum length.

2. Adhesive: As recommended by wheel-stop manufacturer for application to pavement.

2.8 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 211.1 for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

2. Comply with WSDOT Standard Specifications 5-05.3(1).

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 4000 psi (27.6 MPa).

2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.

3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).
C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 4-1/2 percent plus or minus 1.5 percent for 1-1/2-inch (38-mm) nominal maximum aggregate size.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.


2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Comply with WSDOT Standard Specification 6-02.3(4). Furnish batch certificates for each batch discharged and used in the Work.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Comply with WSDOT Standard Specification 6-02.3(4)B.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and base surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below concrete pavements to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Testing Agency, and replace with compacted backfill or fill as directed.

C. Proceed with concrete pavement operations only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

3.2 PREPARATION

A. Remove loose material from compacted base surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.
3.4 JOINTS

A. General: Form construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated. Comply with WSDOT Standard Specification 5-05.3(8).

1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints. Comply with WSDOT Standard Specification 5-05.3(8)C.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated. Comply with WSDOT Standard Specification 5-05.3(8)D.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Comply with WSDOT Standard Specification 5-05.3(8)A. Comply with WSDOT Standard Specification 5-05.3(8)B for sealing sawed contraction joints.

E. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to a radius in accordance with WSDOT Standard Plans. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

F. Tie Bars and Dowel Bars: Comply with WSDOT Standard Specification 5-05.3(10).

3.5 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Remove snow, ice, or frost from base surface before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten base to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with WSDDOT Standard Specification 5-05 and ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

F. Consolidate concrete according to WSDOT Standard Specification 5-05 and ACI 301 by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

G. Screed pavement surfaces with a straightedge and strike off.

H. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

I. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.

J. Cold-Weather Placement: Comply with WSDOT Standard Specification 5-05.3(14), ACI 306.1, and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
   1. Do not use frozen materials or materials containing ice or snow.
   2. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.

K. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
   1. Fog-spray forms and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
   1. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with WSDOT Standard Specification 5-05.3(14) and ACI 306.1 for cold-weather protection.
C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
   1. Moist Curing: Comply with WSDOT Standard Specification 5-05.3(13)C.
   2. Moisture-Retaining-Cover Curing: Comply with WSDOT Standard Specification 5-05.3(13)B.
   3. Curing Compound: Comply with WSDOT Standard Specification 5-05.3(13)A.

3.8 PAVEMENT TOLERANCES

A. Comply with tolerances of WSDOT Standard Specification 5-05, ACI 117 and as follows:
   1. Elevation: 1/4 inch (6 mm).
   2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
   3. Surface: Gap below 10-foot- (3-m-) long, unlevelled straightedge not to exceed 1/4 inch (6 mm).
   4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1 inch (25 mm).
   5. Vertical Alignment of Tie Bars and Dowels: 1/4 inch (6 mm).
   6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2 inch (13 mm).
   7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4 inch per 12 inches (6 mm per 300 mm).
   8. Joint Spacing: 3 inches (75 mm).
   9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
   10. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.9 PAVEMENT MARKING


3.10 WHEEL STOPS

A. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded in holes drilled or cast into wheel stops at one-quarter to one-third points. Firmly bond each dowel to wheel stop and to pavement. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage and pay for a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
B. Field quality control, testing, and inspections shall comply with WSDOT Standard Specifications.

C. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 100 cu. yd. (76 cu. m) or fraction thereof of each concrete mix placed each day.
2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate requirements have not been met.

F. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.12 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.

B. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

C. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

3.13 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

END OF SECTION 321313
SECTION 321400 - UNIT PAVERS

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the following:
   1. Concrete pavers set in aggregate (sand) setting beds.

B. Related Sections include the following:
   1. All other Division 32 Sections.

1.2 SUBMITTALS

A. Product Data: For materials other than water and aggregates.

B. Product Data: For the following:
   1. Concrete Pavers.
   2. Aggregate (Sand) setting materials.
   3. Sealer.

C. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.

D. Samples for Initial Selection: For the following:
   1. Each type of unit paver indicated.
   2. Exposed edge restraints involving color selection.

E. Samples for Verification:
   1. Full-size units of each type of unit paver indicated.
   2. Joint materials (aggregate).

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

B. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
   1. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
C. Installation shall be by a contractor and crew with at least one year of experience in placing interlocking concrete pavers on projects of similar nature and complexity. Contractor shall hold current Basic Level Certificate from the Interlocking Concrete Paving Institute (CPIC) Contractor Certification Program. Contractor shall conform to all local, state/provincial licensing and bonding requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.

B. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

C. Store liquids in tightly closed containers protected from freezing.

1.5 PROJECT CONDITIONS

A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.

PART 2 PRODUCTS

2.1 CONCRETE PAVERS

A. Concrete Pavers: Solid paving units, made from normal-weight concrete with a compressive strength not less than 8000 psi, water absorption not more than 5 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.

1. Basis of Design: Holland Paver, 2-3/8” x 3-15/16” x 7-3/8” as manufactured by Mutual Materials. Color shall be Rustic Blend, selected from manufacturer’s standard colors. Design shall be Herringbone pattern. Local supplier: Mutual Materials Spokane branch, 6721 E Trent Avenue, Spokane, WA 99212. Phone (509) 922-4100.

2.2 AGGREGATE SETTING-BED MATERIALS

A. Graded Aggregate for Subbase: Sound, crushed stone or gravel complying with requirements in Division 32 Section “Earthwork” for subbase material.

B. Sand for Leveling Course: Sound, sharp, washed natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.

C. Sand for Joints: Fine, sharp, washed natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
D. Clear Sealer: Provide clear sealer for exterior surfaces to protect pavers from moisture penetration and prevent product yellowing. Sealer shall provide a natural, non-shiny finish.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 PREPARATION

A. Proof-roll prepared subgrade according to requirements in Division 32 Section “Earthwork” to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive base course for unit pavers.

3.3 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Joint Pattern: Running bond, refer to details.

E. Tolerances: Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and ¼ inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

3.4 AGGREGATE SETTING-BED APPLICATIONS

A. Compact soil subgrade uniformly to at least 95 percent of ASTM D 698 laboratory density.

B. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

C. Place aggregate base, compact to 100 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.
D. Place leveling course and screed to a thickness of 1 inch (25 mm), taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

E. Treat leveling course with herbicide to inhibit growth of grass and weeds.

F. Set pavers with a minimum joint width of 1/16 inch (1.5 mm) and a maximum of 1/8 inch (3 mm), being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed 3/8 inch (10 mm) with pieces cut to fit from full-size unit pavers.

G. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a 3500- to 5000-lbf (16- to 22-kN) compaction force at 80 to 90 Hz. Perform at least three passes across paving with vibrator. Vibrate under the following conditions:

1. After edge pavers are installed and there is a completed surface or before surface is exposed to rain.
2. Before ending each day’s work, fully compact installed concrete pavers to within 36 inches (900 mm) of the laying face. Cover pavers that have not been compacted and leveling course on which pavers have not been placed, with nonstaining plastic sheets to protect them from rain.

H. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.

I. Do not allow traffic on installed pavers until sand has been vibrated into joints.

J. Repeat joint-filling process 30 days later.

3.5 REPAIRING AND CLEANING

A. Remove and replace rock or unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Cleaning: Remove excess sand from exposed paver surfaces; wash and scrub clean.

3.6 SEALING

A. After thoroughly washing and scrubbing paver surfaces, seal area with clear natural-finish sealer.

END OF SECTION 321400
SECTION 328400 - LANDSCAPE IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the installation of a complete underground, automatic irrigation system, including new mainline, new relays and controls, control valves and other new construction. New work involves, but is not limited to: connection to the point of connection, irrigation components and a new controller with conventional wire control system. The system includes but is not limited to; piping, valves, sprinklers, specialty controls, wiring, and one year of maintenance.

B. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.

C. Drain Piping: Downstream from circuit piping drain valves. Piping is not under pressure.

D. Irrigation Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.

E. Where conflicts occur between plan and specification, the more restrictive of the two shall apply.

F. All substitution requests from specified products shall be approved in writing prior to bid date per requirements of Division 1 and the General Conditions.

1.2 EXISTING CONDITIONS

A. Existing Site Conditions: Locations of existing utilities and other improvements shown on the drawings are approximate. Existing conditions shall be verified and should any utilities be encountered during construction, the contractor shall indicate them on the “Record Drawings” with coordinated dimensions from fixed above ground structures and as per depth, size and type of material. The contractor shall always protect existing utilities.

1.3 PERFORMANCE REQUIREMENTS

A. Irrigation zone control shall be automatic operation with controller and automatic control valves, scheduled to complete watering of entire site in 6 hours of operation with 1” of precipitation applied over three days per week of total operating time.

1.4 WARRANTY

A. Contractor shall warranty work and parts for a period of two years beginning on the date of the substantial completion. Any repairs or replacements deemed to be the contractor’s responsibility shall be remedied immediately with originally-specified material and to the
owner’s satisfaction and at no cost to the owner. The contractor shall replace material within 10 days of written notice from owner’s representative. INCLUDE letter of warranty consistent with these terms.

1.5 SUBMITTALS

A. Contractor and Product Data: Prior to starting any work, the contractor shall present for approval by the owner’s representative, three (3) packages of the following information. The submittals shall be neatly bound with a cover letter on the company’s letterhead, indicating the contents and purpose of the submittals. All items shall be provided within one submittal package.

1. Project name and location.
2. Job site foreman’s name that will be responsible for the project at all times.
3. Table of Contents listing all material and equipment to be used on the project indicating brand names, model numbers and or shop drawings. Cut sheets of all the following landscape irrigation items are required.

   a. Certification of training for installer of irrigation control system, provided by manufacturer(s).
   b. Automatic Controller
   c. Backflow prevention device
   d. Quick coupler.
   e. Isolation gate valve.
   f. Galvanized Pipe.
   g. PVC Mainline and Lateral Piping.
   h. Sleeves.
   i. Unions, fittings and joint restraints.
   j. Spray, rotor and drip heads and outlets.
   k. Automatic control valves.
   l. Control wire.
   m. Wire connectors.
   n. Valve boxes and concrete vaults.
   o. Metallic identification ribbon.
   p. Warranties for products and installation
   q. Weather station/sensors.
   r. Grounding rod and wiring.
   s. Irrigation system program schedule(s).
   t. Irrigation record drawing.

B. Operation/Maintenance Manuals:

1. Provide the Owner with two final copies of the Operation and Maintenance Manual for the system. One preliminary copy of the manuals shall be submitted to the Architect for review and approval prior to issuing the two final copies to the Owner. Manuals shall be provided to the Owner prior to the instruction/training session in both hardcopy and electronic (PDF) format.

2. Manuals shall include as a minimum.
a. A master index at the beginning of the manual. Provide tab index sheets separating sections within the manual; correlated to the index.

b. A section containing the name, address, and phone number of the Architect, General Contractor, all subcontractors, all material Suppliers, and the certified installer of the irrigation control system. The listing enclosed shall be numbered or otherwise keyed to the other sections of the manual so that each system component or material item can easily be associated with the appropriate supplier and installer.

c. A section containing a general description of the system, the intended sequence of operation, and the “Record Drawings”. Shall contain all programmed irrigation schedules, including zone numbers, run times, start times.

d. A section containing the operational procedures such as Winterization and spring start-up, and recommended spare parts listings.

e. A section containing technical information about each and every component of the system. This information shall include catalog data clearly marked as to specific model number and/or style device used, exploded parts diagrams for assembled components such as control valves and sprinkler heads, and wiring/control diagrams for all parts of the system.

f. A section containing all manufacturer’s and contractors’ warranties, test reports, and inspection certificates.

C. Record Documents

1. Record accurately and legibly on a daily basis, all changes, additions, deletions, substitutions, discovered utilities and irrigation system components and other irrigation system modifications on a clean set of Construction Documents. Update and review record documents with Architect during each site observation meetings/visit.

2. Provide the completed original markup drawings to the Owner and a copy to the Architect at the completion of the work, prior to application for final payment. Record drawings are required in hardcopy, electronic and PDF format on CD, at the same scale as the original design drawings.

   a. Indicate locations, sizes and kinds of equipment installed.

   b. Dimension from 2 permanent points of reference (building corners, sidewalk, or road intersections, etc.) the location of the following items:

      1. Connection to water lines.
      2. Connection to electrical power.
      3. Controller location.
      4. Control wiring locations, including control wire to valve routing, location of ground rods and other accessories.
      5. Location of Control Valves, Gate and/or Isolation valves.
      6. Routing of sprinkler pressure lines (dimension max. 100' along routing).
      7. Location of lateral lines.

     10. Drawings shall contain correctly numbered and indexed valve numbering, corresponding to irrigation control programming, valve and equipment numbering, and completed in a logical sequence corresponding to the path of the mainline from the point of connection forward.

     11. Drawings shall contain valve schedules, containing anticipated zone run times for each program on the controller, expected flows per zone, etc.
3. Controller Charts:
   a. Record Drawings shall be approved by the Owner/Landscape Architect before controller charts are prepared. Record drawings and controller charts shall match with regards to layout, valve information, scheduling, sequencing, etc.
   b. Submit 1 complete set of controller charts for each controller.
   c. Contractor shall supply two hermetically sealed reproductions of record drawings to fit an eleven by seventeen format. All zones will be color coded for ease of identification. One copy shall be mounted on the wall next to the controller and one copy given to Owner’s facilities department.
   d. Chart shall be a full-sized print, or high-quality photocopy. Use a different color to indicate different zones and its respective area of coverage.
   e. When approved, hermetically seal chart between 2 pieces of plastic (20mil) and securely mount to wall near controller enclosure.
   f. Electronic files shall be provided to the Owner and Landscape Architect.

1.6 QUALITY ASSURANCE
   A. 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.
   B. Certified Tester shall test the “Backflow Prevention” devices per local City and State requirements and the successful results shall be forwarded to the owner.
   C. Irrigation control system shall be installed by a certified installer. Certification and training shall be provided by the manufacturer of the control system. Provide certificate of training to Owner’s representative.

1.7 COMMISSIONING
   A. Commissioning services shall be completed by the Landscape Architect, and shall include but not be limited to the following: certification of system operational parameters, completion of system construction and installation per manufacturer’s requirements and specifications; system coverage; system programming; activation and winterization procedures; review of all submittal information, record drawings and operations and maintenance manuals.

1.8 INSTRUCTION AND TRAINING
   A. Upon completion of the installation, provide a minimum of four (4) hours of instruction to the Owner’s personnel in the correct maintenance, operation, and repair of the system and all its components. Instructions shall include a visual inspection and locating tour of the system. The Operations/Maintenance Manuals shall be completed and provided to the Owner prior to the instruction period. The Owner will make the Manuals available for use during the instruction periods.
   B. Instructions shall include hands-on training in the troubleshooting, repair and replacement procedures for each system component.
1.9 FIRST WINTERIZATION AND SPRING START-UP

A. The following is a recommendation for winterizing and start up of the irrigation system. Contractor shall use accepted industry practices for both winterization and startup.

B. First Winterization

1. Coordinate winterization process with appropriate Owner personnel. Provide 48 hours notice of shut-down. All appropriate personnel shall be present during the shutdown process.
2. Notify the Owner in writing that the system Winterization is complete and that the backflow prevention device may be secured.

C. Spring Start-Up

1. Upon notification by the Owner, return to the work site and start up the irrigation system as follows.
   a. Visually inspect the system for winter damage, and repair/replace any damaged devices, piping, etc.
   b. Schedule with the Owner to have the backflow prevention device put back into service.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
3. Domestic Manufacture: US manufacture is required. Provide certification on point of origin for all products herein.

2.2 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: Galvanized Schedule 40, standard threaded, ASTM A120 to 30’ past point of connection.


2. Use PVC solvent cement compatible with PVC pipe. (NO quick-drying cement permitted.)

C. Transition Fittings: Refer to Division 22 Section "General Plumbing Provisions".

D. Refer to Division 22 “Plumbing” for commonly used joining materials.

2.3 SLEEVES

A. All PVC ‘sleeve’ pipe under pavements and roadways shall be Class 200, ASTM D 1784 or 5.

B. Sleeves shall be 4" diameter for all piping up to 2.5” and 6” diameter for all 3” and larger piping; or if not called out a minimum of twice the size as the inserted pipe. Provide separate 2" sleeves under all hard surfaces for irrigation wiring.

C. Wire Splices: Seal connection will be 3M Scotchcast product #3570, Spears DS-100w/DS300 sealant, splice connector or an approved equal. Wire splices shall be fully contained within approved sealed connections, with adequate wiring exposed to facilitate connection, joint sealing covers fully secured, and joint sealing covers tightly wrapped in electrical tape. Joint sealing devices shall be properly sized for wire gauges used, wire quantity being secured, etc. according to manufacturer’s installation instructions.

D. Sleeves shall be identified on both sides of crossing under paved surfaces with rebar-type identification pins. See Detail.

2.4 SPECIALTY VALVES

A. Plastic Automatic Control Valves: Molded-plastic body, normally closed, diaphragm type with manual flow adjustment, and operated by 24-V ac solenoid.


B. Isolation Valves: Non-Rising Stem, resilient wedge (flanged for 2.5” or greater and Schedule 80 Unions for 2” or smaller. Valves shall be Model T-113 as manufactured by Nibco or equivalent as approved by owner.

C. Ball Valves: Install ball valve ahead of each electric control valve, line sized, for isolating each zone.

D. Quick-Couplers: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5 NH threads for garden hose on outlet; and operating key.

1. Manufacturers:
   a. Hunter HQ-44LRC
E. Polymer (Thermoplastic) Valve Boxes: Polymer type rectangular 15" x 21.5" x 12" deep with lock down cover with lettering “IRRIGATION” on top. Round valve boxes, 10" diameter top access, shall be used for quick-coupler or main-line isolation valves only.

1. Manufacturers:
   a. Carson Specification grade series or approved equal.

F. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch (19 mm) minimum to 1 inches (26 mm) maximum.

2.6 SPRINKLERS AND OUTLETS

A. Description: Plastic housing and corrosion-resistant interior parts designed for uniform coverage over entire area indicated, at available water pressure.

1. Hunter products only are pre-approved. Any proposed change from Hunter required pre-approval.
2. Pop-up spray type with various patterns: Hunter PRO-S, commercial grade.
3. Drip emitters: Hunter HE-B or approved equal

2.7 AUTOMATIC-CONTROL SYSTEM

A. New controller to be Hunter ACC, interior wall mount, grey metal finish. Provide AGM-600 Extreme Service output modules as needed for zone control wiring. Provide Flow-Sync flow sensing capability at point of connection; provide Solar Sync wireless ET/rain sensor; ROAM-XL remote control

1. Control Wire: 24 volt solid wire, UF No. 14 AWG minimum, UL approved for direct burial in ground. No. 14 wire for up to 1000’ and No. 12 wire above 1000’ length. Exposed control wire to the controller shall only be placed in Electrical Metallic Tubing (EMT) conduit for interior building locations and PVC pipe for exterior building locations. Wire loops shall be provided at each valve box installation, 24” minimum length.
2. Splicing Materials: Manufacturer's packaged kit designed specifically for use in conventional-type irrigation control systems, suitable for direct burial. All wire splices to be placed in rectangular locking valve box and located correctly on ‘Record Drawings’.

PART 3 - EXECUTION

3.1 INSTALLATION-GENERAL

A. Backflow Preventer: Backflow preventer as called out by civil, installed in available in water service vault at northwest point of connection on site.

B. Trenching: All trenches shall be open, vertical construction, sufficiently wide enough to provide ample working space and at depths as specified. Trenching around roots shall be hand
excavated to pipe depth when roots of 2 inches in diameter or greater are encountered. Trench width shall be 4 inches minimum or 1-1/2 times the diameter of the pipe or whichever is wider.

1. Trenches shall be kept clean of debris, rocks and backfill during installation process and until mains and laterals have been reviewed and approved by the landscape architect and owners' representatives.

C. Backfill: All work must be inspected, tested and approved by the owner's representative prior to backfilling. Backfill shall be thoroughly tamped to 80% to 85% modified proctor. All backfill in turf areas shall proceed as follows: (No Deviations): Place first lift (1/2 of trench depth) in trench and flood to settle. Final lift shall be placed and compacted even with finish grade. The contractor shall encase all PVC pipe within a 3” layer in all directions, with clean sand before commencing with the backfill process.

D. After backfill and appropriate compaction, trenches shall be level with adjacent grades and indistinguishable from remainder of site.

3.2 INSTALLATION-PIPING

A. Install piping and wiring in sleeves under all hard surfaces.

B. Install warning tape directly above pressure piping, 12 inches (300 mm) below finished grades, except 6 inches (150 mm) below subgrade under pavement and slabs.

C. Drain Pockets: Excavate to sizes indicated. Back fill with cleaned gravel or crushed stone, graded from 3/4 to 3 inches (19 to 75 mm), to 12 inches (300 mm) below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.

D. Provide minimum cover over top of underground piping according to the following:

1. Cover over Irrigation Main Piping and control wires: Not less than 24 inches.
2. Cover over lateral lines: Not less than 18 inches.
3. Cover sleeves (all lines): 24” deep from top of base rock under roads (bottom of pavement). Sleeves under sidewalks shall match proposed mainline and lateral depths.

E. Install piping free of sags and bends. Pipe shall have a firm, uniform bearing for the entire length of each pipeline to prevent uneven settlement. Wedging or blocking of pipe shall not be permitted.

F. Install groups of pipes parallel to each other, spaced to permit valve servicing.

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

H. Install unions on either side of valves and to final connections to other components.

I. Provide concrete thrust blocks at all changes in direction in mainline piping, with 5 gallons of concrete required per thrust block. Mainlines smaller than 2” are not required to be thrust-blocked. Thrust blocks shall be poured around pipe, after pipe is enclosed in filter fabric or plastic sheeting.
J. Plastic pipe and fittings: solvent welded using solvents and methods as recommended by manufacturer of the pipe, except where threaded connections are required. Pipe and fittings shall be thoroughly cleaned of dirt, dust and moisture before applying solvent with a non-synthetic brush. Primer and solvent shall be applied so that a small, clean bead of same shall be visible. Other than this type of treatment shall be considered an “unfit” installation and shall be requested to do-over. Make all connections between plastic pipe and metal valves or pipe with teflon tape using plastic male adapters.

K. Pipe Assembly: pipe may be assembled and welded outside of the trench. Snake pipe from side to side in trench bottom to allow for expansion and contraction. ALL MARKINGS SHALL FACE UP FOR EASE OF READING.

3.3 INSTALLATION-VALVES

A. Underground Gate Valves: Install in valve box with valve box top flush with grade; provide minimum clearance between valve box cover and top of valve as shown on Drawings.


C. Control Valves:

1. Install in control-valve box.
2. Valve shall be installed with swing joint consisting of schedule 80 nipples and galvanized elbows.
3. Install remote control valves within landscape areas.
4. DO NOT piggy-back valves.
5. Control valves shall be no deeper than 18” from top of pipe leaving valve to finished grade.
6. Valve shall be identified with brass tag with zone number attached to valve, coordinated with as-built drawings and controller chart.
7. Tee for valve will be taken off the side of the main line (not the top) and the tee will be large enough to use a slip-by threaded bushing instead of a tapped tee.
8. Place within 24” to paved edges of sidewalks, roads or parking lot curbs in a neat and orderly fashion.
9. Valve boxes shall be installed so that the box cover will follow the proposed slopes and contours. (flush with slopes) This may require more than one-extension box. This will occur in all turf grass areas only not in shrub beds or groundcover areas.
10. No valve boxes shall be allowed in the bottom or within 18” of the bottom of swales.
11. Provide 4 bricks per valve box for support.
13. Valve box lids shall be secured with a bolt.

D. Drain Valves: Install in control-valve box.

E. Valve boxes shall be placed in a neat, orderly fashion, no closer than 12" apart and shall be placed with consideration to mowing and upkeep on adjacent areas (i.e., not on sloped planted areas). Valve boxes shall be installed on solid bricks at each corner of the box for stability.

F. Flush circuit piping with full head of water and install sprinklers after hydrostatic test is completed.
G. Quick coupler valves:
   1. Locate as shown on the drawings, except where existing conditions prohibit, or to better suit field conditions, and to achieve as good, or better, coverage under the same conditions.
   2. Change without the owner’s representative’s consent is subject to disapproval and may require replacement at no extra charge to the owner.
   3. Quick couplers shall be as specified with pre-manufactured swing joint assemblies on 10” round boxes.

3.4 CONTROLS, WIRING AND CONNECTIONS

A. Install control wires at same depth as main line pipe, and lay to the side of main line. Provide 24" minimum, looped slack wire within each control valve box and at 100’ intervals, and snake wires in trench to allow for contraction of wires. Control wire harness shall be looped throughout system. Program remote control valves at controller in sequence as shown on drawings.

B. Low voltage control wire shall be placed in a minimum 3” diameter sleeve (dedicated, with no zone or main piping in sleeve), unless otherwise noted. All sleeves shall extend a minimum 12” beyond paved edge.

C. All splices are to be in valve boxes only. Connect wire together with approved connector only within valve boxes. No direct burial of wire connections.

D. Seal connection with approved sealing pack (see details). The path of the control wire shall be indicated on the "Record Drawings", by the landscape contractor. Exposed control wire to the controller shall be placed in an Electrical Metallic Tubing (EMT) for interior building locations and PVC Sch. 40 pipe for exterior building locations.

E. All control wire shall be labeled within the controller at the point of each station connection. Identify valve station number to match sprinkler diagram. Wire identifications shall be located adjacent to connection point at each end and easily visible. Marking system shall include permanent valve tags affixed to each valve.

F. Automatic controller: Locate and install as shown on drawing and as directed by owner's representative. A reduced copy of the “Record Drawings” shall be laminated and adhered to the cabinet door for ease of viewing. The copy shall be colored to indicate which control valve operates which lateral line.

G. Ground equipment according to manufacturer’s requirements for irrigation control system and additional equipment as required.

H. Wire splices are to be located in valve box and identified in ‘record drawings’.

3.5 LABELING AND IDENTIFYING

A. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tape over underground pressure piping, during backfilling of trenches.
B. Refer to Division 31 Section "Earthwork" for warning tapes.

3.6 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Mainline Pressure Test: After installation of mainline and electronic valves, and prior to backfilling any pipe joints, charge system to 100 psi for one hour and test for leaks under the supervision of both the Landscape Architect. Provide a minimum of 24 hours notice prior to test. If any pipe connections have been buried, testing will be rescheduled once all joints are visible. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace units and retest as specified above.

3.7 ADDITIONAL SERVICES OF DESIGN PROFESSIONAL

A. The Landscape Architect will visit the site to conduct routine inspections and observations on a scheduled basis. The contractor shall contact the design professional not less than 24 hours in advance to schedule required inspections. Should inspections fail and a re-inspection process be required, the contractor shall reimburse the design professional for time and expenses incurred for the reinspection process at a stated rate of $125.00 per hour plus travel expenses. Should additional inspections be required for re-review of punchlist items, similar fees will be charged to the contractor.

3.8 HYDROSTATIC TESTS

A. Hydrostatic Tests:

1. Request the presence of the owner's representative at least forty-eight (48) hours in advance of testing.

2. Testing shall be accomplished under this section in the presence of the owner's representative. The backflow preventer shall be tested and approved by a certified contractor as to its working condition and the certificate shall be presented to the owner.

3. Center load piping with backfill to prevent arching or slipping under pressure. All joints, except those concealed by sleeves, shall be visible for testing.

4. Apply continuous water pressure of 100 psi after welded plastic joints have cured at least 24 hours, and with the risers capped as follows: All main-lines shall be tested for two hours. All laterals shall be tested with static pressure only for 1 hour. Repair all defects.

3.9 COMMISSIONING

A. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Landscape Architect.
1. Record drawings/As-Builts shall be fully complete and provided for commissioning services per the requirements of paragraph 1.05 above.
2. Backflow prevention devices shall be checked for installation in conformance with regulatory authorities and certified as being tested and acceptable for use prior to the start of commissioning operations.
3. System shall be filled with water.
4. Controls shall be fully powered with permanent power, grounding and certifications prepared by manufacturers’ representatives.
5. Static pressure test shall be conducted with system pressurized via independent pump, and system isolated from regular source. System to be pressurized to 100 PSI for 15 minutes. Failure to maintain 100 PSI over 15 minute period shall be recognized as a failure in the system which must be rectified prior to continuing commissioning operations.
6. Valve box/vaults shall be opened for unrestricted inspection. Valve boxes/vaults shall be reviewed for cleanliness, required components, wiring connections and grounding, clearances, proper installation and support, required drain rock/gravel, and required valve numbering.
7. Irrigation laterals shall be checked for installation of sprinkler heads per original design as prepared or modified in a conformed set of drawings; layout per the record drawings; coverage of sprinkler heads, proper pressure operation; correct nozzles; complete installation of heads and protective covers; installation of drains, quick couplers and required labeling coordinated with record drawings and control system charts.
8. Irrigation laterals shall be tested for pressure under operation in the presence of the landscape architect via removal of an irrigation head and installation of a pressure gauge.
9. Outlets shall be checked for output, spray pattern, flow rate, and relation to the plant and finished grade.
10. Isolation valves shall be checked for operation during irrigation system functional tests.
11. Control system shall include required grounding, and shall be fully programmed for initial system (grow-in) watering program; ‘cool weather’ and ‘hot weather’ programming in addition to meeting the watering window requirements as stated on the plans and within these Specifications. Control valves shall be logically numbered on the record drawings and coordinated with the station numbers on the controller; with all programs provided at the controller in laminated sheets. Controller programming shall include at a minimum:
   a. Valve station number.
   b. Start time.
   c. Station duration.
   d. Station gallons-per-minute.
   e. Station days-per-week of operation.
   f. Cycle and Soak functions to minimize runoff.
12. Control system shall be checked for: high-flow and low-flow operations within range of designed system; variable speed drive operation; and emergency operations such as a pipe break, power failure, filter failure, etc.
13. Network connectivity, telemetry, weather station operations shall be verified with Owner personnel present.
14. Commissioning operations shall include a walk through of system winterization procedures and spring activation procedures.
A. Adjust settings of controllers.

B. Adjust automatic control valves to provide flow rate of rated operating pressure required for each sprinkler circuit.

C. Maintenance Service: Maintenance Period: Landscape and irrigation maintenance shall be performed for 12 months from date of substantial completion per the requirements of this Section and Section 32 9301.

D. Contractor shall include coordination with irrigation controller manufacturer for the commissioning and scheduling and training prior to final completion.

END OF SECTION 328400
SECTION 329119 - LANDSCAPE GRADING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Final grade topsoil for finished landscaping.

1.2 RELATED SECTIONS

A. All other Division 32 Sections.

1.3 SUBMITTALS

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

1. Imported Topsoil Analysis: Provide topsoil analysis showing as a minimum; pH, textural composition by percentage, N-P-K-S by parts per million, micronutrient analysis, soluble salts (sulfate), Cation Exchange Capacity, and organic matter content. Acceptance of material is subject to meeting or exceeding all conditions.

B. Samples:

1. Topsoil
   a. Submit 1/2 gallon bucket sample for review and approval by the Landscape Architect.

2. Infiltration swale topsoil
   a. Submit 1/2 gallon bucket sample for review and approval by the Civil Engineer.

PART 2 PRODUCTS

2.1 TOPSOIL MATERIAL

A. Native Topsoil: Material stripped and stockpiled, free of rocks larger than 1”, sod, roots, and construction debris.

B. Imported Topsoil: Where native topsoil is not available in sufficient quantities for re-use on site, the following are approved for use as imported materials:

1. Shrub Areas: Wittkopf Commercial Topsoil Soil or approved equal.
2. Stormwater Swales: Wittkopf Commercial Topsoil Barr-Tech Mix or approved equal.
PART 3 EXECUTION

3.1 EXAMINATION

A. Verify building and trench backfilling have been inspected.

B. Verify subgrade has been ripped, contoured and properly compacted according to the grading plan(s). Ensure that no landscape areas have been compacted to more than 85% relative to the soil types encountered.

C. Prior to installation of irrigation system and/or placing any topsoil in swale areas, all swales shall be flooded with water through normal inlets to test subgrade drainage. Test shall begin when swale is inundated to a depth adequate to reach drywell rim, and shall be timed to end when water has drained from swale.

   1. Should water not drain within 72 hours, contractor shall rip or otherwise excavate swale bottom to loosen soil and provide adequate drainage. Swales that do not drain shall be retested after soil excavation/ripping.

3.2 SUBSTRATE PREPARATION

A. Eliminate uneven areas, high points and low spots. Subgrade elevations must be within 1” tolerances.

B. Remove debris, roots, branches, stones, in excess of 1 inch in size. Remove subsoil contaminated with

   1. Petroleum products
   2. Building debris.
   3. Painting products
   4. Concrete waste

C. Thoroughly rip sub-grade to a minimum depth of 6” prior to placing topsoil. 12” in those areas determined by the Owner/Landscape Architect to have been overly compacted or contaminated during the construction process. Ripping may be accomplished by a toothed implement or by tilling. Perform this operation in all areas and while either the Owner or the Landscape Architect is present.

D. Subgrade compaction shall not be more than 85% in any areas scheduled for topsoil.

E. Topsoil compaction shall not be more than 85%.

F. Contractor to provide compaction testing results for any area, or areas chosen by the Landscape Architect or Owner throughout the site, and at any time during the course of construction. Tests must be accomplished within a 48-hour period. The installation of topsoil shall not continue until satisfactory test results have been presented the Landscape Architect and written acceptance of said results by Landscape Architect have been delivered to the Owner.

3.3 PLACING TOPSOIL
A. Place topsoil in areas where landscaping is required to a depth as specified on drawings for landscape beds and lawn areas. Place topsoil during dry weather only. Existing topsoil may be used in lieu of import if adequate stockpiles exist. Should on-site topsoil not exist for re-use, provide import topsoil per requirements herein.

B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.

C. Remove roots, weeds, rocks, and foreign material while spreading.

D. Manually spread topsoil close to plant life, and finished structures to prevent damage.

E. Ensure that areas compacted by placement of topsoil or other trades are ripped, rototilled and loosened to maintain drainage and a non-compacted condition acceptable to plant life.

F. Remove surplus subsoil and topsoil from site.

G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.4 TOLERANCES
   A. Top of Topsoil: Plus or minus 1” in 10 feet.
   B. Thickness of Topsoil: Plus or minus 1/2”.
   C. Changes in grades are to be made gradual and smooth without abrupt edges or ridges to insure proper mowing conditions and gentle slopes.

3.5 PROTECTION
   A. Protect landscaping and other features remaining as final work.
   B. Protect existing structures, fences, sidewalks, utilities, paving, and curbs.
   C. Repair eroded areas during construction.

END OF SECTION 329119
SECTION 329300 - PLANTS

PART 1 GENERAL

1.1 SECTION INCLUDES
   A. Topsoil bedding within landscape areas shown on drawings.
   B. New trees, plants and ground cover.
   C. Edging, mulch and fertilizer.
   D. Maintenance.

1.2 RELATED SECTIONS
   A. All other Division 32 sections.

1.3 REFERENCES
   A. ANSI Z60.1 - Nursery Stock.

1.4 DEFINITIONS
   A. Weeds: Any plant material not shown or specified.
   B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1 and as described herein. Material shall be “specimen” grade, fully branched, equally developed, similar to identical in form, density, branching structure; trees shall be ‘matched’ in terms of branching height, canopy density. Plant material that is damaged, including broken branches, cuts to trunks or stems shall be removed and replaced immediately. Trees shall arrive at the site in good condition, with no evidence of stress, damage, loss of leaves due to adverse conditions at the storage or growing facility; free of damage due to travel, shipment and handling. No trees shall be provided that have adventitious roots.

1.5 SUBMITTALS
   B. Maintenance Data: Include cutting and trimming method; types, application frequency, and recommended coverage of fertilizer.
   C. Submit list of plant life sources.
   D. Product data or samples of all items defined in this section.
1.6 QUALITY ASSURANCE

A. Nursery Qualifications: Company specializing in growing and cultivating the plants with three years documented experience.

B. Installer Qualifications: Company specializing in installing and planting the plants with minimum three years documented experience and approved by nursery, located within a 50 mile radius of the project site. Submit documentation illustrating experience on similarly sized projects within the 50 mile radius area. Submit evidence of insurance and level of bonding available.

C. Maintenance Services: Performed by installer for 90 days date of Substantial Completion.

D. Contractor shall verify quantities of plant materials and immediately notify Landscape Architect of discrepancies.

E. Where conflicts between specifications and plans occur, the more restrictive shall apply.

1.7 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition.

B. Provide certificate of compliance from authority having jurisdiction indicating approval of plants, fertilizer mixture.

C. Plant Materials: Certified by state department of agriculture, free of disease or hazardous insects. Meeting all conditions and requirements for American Standards for Nursery Stock.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

C. Protect and maintain plant life until planted.

D. Deliver plant life materials immediately prior to placement. Keep plants moist.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Do not install plant life when ambient temperatures may drop below 35° or above 95° F for more than 48 hours.

B. Do not install plant life when wind velocity exceeds 30 mph.
1.10 COORDINATION

A. Coordinate work under provisions of Division 1.

B. Install plant life after and coordinate with installation of underground irrigation system piping and water heads specified in Section 328401 "Landscape Irrigation."

1.11 WARRANTY

A. Provide one year warranty under provisions of Division 1.

B. Include coverage for one continuous growing season from date of substantial completion for entire project. Replace dead or unhealthy plants throughout length of the project and warranty period.

C. Replacements: Plants of same size and species as specified, planted in the next growing season, with a new warranty commencing on date of replacement.

1.12 MAINTENANCE SERVICE

A. Refer to Section 329301 "Landscape Maintenance."

1.13 DESIGN PROFESSIONAL ADDITIONAL SERVICES

A. Contractor shall be responsible for costs incurred by the Owner for additional services provided by the prime and collaborating design professionals directly related to work found to be in non-conformance with the contract documents. Reinspection of defective work, repeated site inspections to verify completion of punch list items, warranty items, repairs and failed inspections will be charged to the landscape contractor at the rate of $150.00 per hour.

PART 2 PRODUCTS

2.1 TREES, PLANTS, AND GROUND COVER

A. Trees, Plants and Ground Cover: Species and size identifiable in plant schedule, grown in climatic conditions similar to those in locality of the Work, unless otherwise stated, specimen quality/grade, undamaged by handling defects, weather or nursery conditions.

2.2 SOIL MATERIALS

A. Topsoil: As specified in Section 329119 "Landscape Grading."
2.3 SOIL AMENDMENT MATERIALS

A. Fertilizer: Containing fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil to the following proportions: Nitrogen 10 percent, phosphoric acid 15 percent, soluble potash 10 percent, sulfur 10 percent.

B. Peat Moss: Shredded, loose, sphagnum moss; free of lumps, roots, inorganic material or acidic materials; minimum of 85 percent organic material measured by oven dry weight, pH range of 4 to 5; moisture content of 30 percent.

2.4 ACCESSORIES

A. Tree Wrapping Material: Wrapping material shall be 4" wide coated paper tree wrap. Clark's Tree Wrap manufactured by: Walter E. Clark & Son; local distributor Cascade Seed, Ph. (509) 534-9431. Submit sample for approval.

B. Stakes: Softwood lumber, pointed end.

C. Tree Chain: Chain Lock Tree Ties one inch wide to withstand wind pressure and resultant movement of plant life. Chain Lock Tree Ties manufactured by: Mastermark; local distributor Wilbur-Ellis Co., Ph. (509) 928-4512. Submit sample for approval.

D. Tree Anchor: Support 3" caliper and larger trees with 2x4 deadmen as detailed on the Drawings.

E. Rock Mulch: Basalt chip mulch, approved by owner prior to delivery to site.

F. Nonwoven Geotextile Weed Barrier Fabric: Spunbond polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, as manufactured by TurfGro or equivalent as approved by owner. Used under all mulch areas and under loose-fill playground resilient surfacing.

2.5 PLANT SOIL MIX

A. Refer to Section 329119 "Landscape Grading" for basic soil product. Blend 70% soil mix with 30% peat moss for planting pits in shrub and tree areas.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that prepared subsoil and planters are ready to receive work.

B. Verify that applicable permits from City of Spokane Urban Forestry have been obtained and are available for inspection.

C. Saturate soil with water to test drainage.

D. Verify that required underground utilities are available, in proper location, and ready for use.
E. Planting operations shall take place when weather conditions will not adversely affect plant material, and after plant material has become acclimated to the Spokane area. Planting shall not take place when temperatures exceed 90°; when wind on site is greater than 25 miles per hour, or when sub freezing conditions occur.

F. Plants shall be treated with appropriate anti-dessicant materials prior to shipment and planting.

G. Plants that are damaged due to shipping, weather or mechanical injury shall not be planted and shall be immediately removed from the site and replaced.

3.2 PLACING TOPSOIL

A. Refer to Section 329119 "Landscape Grading."

3.3 FERTILIZING

A. Apply fertilizer in accordance with manufacturer's instructions.

B. Apply after initial raking of topsoil.

C. Mix thoroughly into upper 2 inches of topsoil.

D. Lightly water to aid the dissipation of fertilizer.

E. Apply at a rate defined in Section 329200 "Lawns and Grasses" for seeded areas.

F. Apply to each tree and shrub as recommended by manufacturer

3.4 PLANTING

A. Place plants for best appearance for review and final orientation by Landscape Architect.

B. Set plants vertical.

C. Remove non-biodegradable root containers.

D. Set plants in pits or beds, partly filled with prepared plant mix, as indicated on drawings under each plant. Cut and loosen burlap, ropes, and wires, from the root ball after installation but prior to backfilling.

E. Saturate soil with water when the pit or bed is half full of top-soil and again when full.

3.5 PLANT RELOCATION AND RE-PLANTING

A. Re-locate plants as directed by Landscape Architect.
3.6 INSTALLATION OF ACCESSORIES

A. Install weed-barrier fabric, with decorative cover.

B. Wrap deciduous shade and flowering tree trunks and place tree protectors as shown on planting details as applicable.

C. Install mulch to a depth of 2” in all shrub planting areas, and 1” in all groundcover planting areas.

3.7 PLANT SUPPORT

A. As determined by the contractor’s Certified Arborist, provide tree staking per the following and per details and notes on the Drawings:

<table>
<thead>
<tr>
<th>Tree Caliper</th>
<th>Tree Support Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inch (25 mm)</td>
<td>2 stakes with two ties</td>
</tr>
<tr>
<td>1.5 - 2.5 inches (25 - 50 mm)</td>
<td>3 stakes with three ties</td>
</tr>
<tr>
<td>3 - 4 inches (50 - 100 mm)</td>
<td>3 deadmen</td>
</tr>
<tr>
<td>Over 4 inches (100 mm)</td>
<td>4 deadmen</td>
</tr>
</tbody>
</table>

3.8 FIELD QUALITY CONTROL

A. Division 1 - Administrative Requirements.

B. Plants will be rejected if a ball of earth surrounding roots has been disturbed or damaged prior to or during planting.

C. Plants will be rejected if stressed or are dying due to improper handling during installation.

END OF SECTION 329300
SECTION 329301 - LANDSCAPE MAINTENANCE

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish all labor, material and equipment necessary to provide complete and continuous maintenance of all trees, shrubs, groundcovers, lawns, vines, perennial and annual plants, and all other work connected thereto and as herein specified.

B. Maintenance Period: 90 days after substantial completion.

1. For multiple phase projects, maintenance period is 90 days after substantial completion for each phase, as approved by the Owner.

1.2 RELATED SECTIONS

A. All other Division 32 sections.

1.3 TESTING

A. Soils testing are required on an annual basis for general lawn areas and playfields. Soils tests shall include the collection of multiple samples per target area, aggregation of those samples into a common container, and testing of the samples for nutrients, pH levels, organic matter and trace elements, as well as mechanical composition.

1.4 DEFINITIONS


B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1 and as described herein. Material shall be “specimen” grade, fully branched, equally developed, similar to identical in form, density, branching structure; trees shall be ‘matched’ in terms of branching height, canopy density. Plant material that is damaged, including broken branches, cuts to trunks or stems shall be removed and replaced immediately. Trees shall arrive at the site in good condition, with no evidence of stress, damage, loss of leaves due to adverse conditions at the storage or growing facility; free of damage due to travel, shipment and handling. No trees shall be provided that have adventitious roots.
1.5 SUBMITTALS


B. Maintenance Data: Provide spreadsheet-based proposed maintenance schedule, including anticipated dates for application of dormant spray; irrigation system activation; spring aeration and fertilization; spring pest and weed control; spring pruning, trimming and cleanup; mowing and trimming schedule by time of day and day of week (to be coordinated with Owner’s approval); interim weed control and litter pickup; summer and fall fertilizations; seasonal irrigation adjustments; fall cleanup of leaves, needles, weeds and litter; and irrigation system winterization.

C. Product data or samples of all items defined in this section, including fertilizer, herbicides, pesticides and additional nutrients.

1.6 QUALITY ASSURANCE

A. Qualifications: Maintenance personnel trained in landscape care, including mowing, trimming, pruning and thinning; application of fertilizers, herbicides and pesticides with applicable State certifications.

1.7 REGULATORY REQUIREMENTS

A. Comply with regulatory agencies for fertilizer and herbicide composition, with applications completed by a certified applicator.

B. Workers on site must conform to Owner’s requirements for contractors, including use of required safety equipment, background checks, proper training in the use of all equipment, etc.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1.

B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.9 COORDINATION

A. Coordinate work under provisions of Division 1.

B. Maintenance operations shall be completed regularly per the schedule approved by the Owner.

1.10 WARRANTY

A. Provide one year warranty under provisions of Division 1.
B. Include coverage for one continuous growing season from date of substantial completion for entire project. Replace dead or unhealthy plants throughout length of the project and warranty period.

C. Replacements: Plants of same size and species as specified, planted in the next growing season, with a new warranty commencing on date of replacement.

1.11 DESIGN PROFESSIONAL ADDITIONAL SERVICES

A. Contractor shall be responsible for costs incurred by the Owner for additional services provided by the prime and collaborating design professionals directly related to work found to be in non-conformance with the contract documents.

PART 2 PRODUCTS

2.1 TREES, PLANTS, AND GROUND COVER

A. Replacement Trees, Plants and Ground Cover: Species and size identifiable in plant schedule, grown in climatic conditions similar to those in locality of the Work.

2.2 SOIL MATERIALS

A. Topsoil: As specified in Section 329119 "Landscape Grading."

2.3 SOIL AMENDMENT MATERIALS

A. Fertilizer: Containing fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil.

B. Sulfur: Granular sulfur, to be used as a pH modifier.

2.4 ACCESSORIES

A. Tree Wrapping Material: Wrapping material shall be 4" wide coated paper tree wrap. Clark's Tree Wrap manufactured by: Walter E. Clark & Son; local distributor Cascade Seed, Ph. (509) 534-9431. Submit sample for approval.

B. Stakes: Softwood lumber, pointed end. Remove stakes at completion of one year warranty period.

C. Tree Chain: Chain Lock Tree Ties one inch wide to withstand wind pressure and resultant movement of plant life. Chain Lock Tree Ties manufactured by: Mastermark; local distributor Wilbur-Ellis Co., Ph. (509) 928-4512. Submit sample for approval.

D. Tree Anchor: Support 3" caliper and larger trees with 2x4 deadmen as detailed on the Drawings.
E. Replacement Mulch: Match existing installed at original construction.

F. Nonwoven Geotextile Filter Fabric: Where used, spunbond polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, as manufactured by TurfGro or equivalent as approved by owner.

G. Replacement Concrete Lawn Edging: Match existing.

2.5 PLANT SOIL MIX

A. Refer to Section 329119 "Landscape Grading" for basic soil product. Blend 70% soil mix with 30% peat moss for planting pits in shrub and tree areas.

PART 3 EXECUTION

3.1 MAINTENANCE SERVICE

A. Furnish service and maintenance for 90 days after Date of Substantial Completion.

B. Maintenance to include:

1. Cultivation and weeding plant beds and tree pits.
2. Applying herbicides for weed control in accordance with manufacturer's instructions. Remedy damage resulting from use of herbicides.
3. Remedy damage from use of insecticides.
4. Irrigation scheduling and monitoring to sufficiently to saturate root system.
5. Pruning and thinning, including removal of dead or broken branches, and treatment of pruned areas or other wounds.
6. Disease control.
7. Maintaining wrapping, guys, turnbuckles, and stakes. Adjust turnbuckles to keep guy wires tight. Repair or replace accessories when required.
8. Replacement of mulch.
9. Repair of eroded areas.
10. Shearing of trees and shrubs is strictly prohibited and may result in the replacement of the sheared material with a new tree or shrub after inspection by the Landscape Architect.

C. Planting operations shall take place when weather conditions will not adversely affect plant material, and after plant material has become acclimated to the Spokane area. Planting shall not take place when temperatures exceed 90º; when wind on site is greater than 25 miles per hour, or when sub freezing conditions occur.

D. Plants shall be treated with appropriate anti-desiccant materials prior to shipment and planting.

E. Plants that are damaged due to shipping, weather or mechanical injury shall not be planted and shall be immediately removed from the site and replaced.
3.2 **FERTILIZING**

A. Apply fertilizer in accordance with manufacturer's instructions. Lawn fertilizer shall be applied multiple times per year. General fertilizer recommendation is for turfgrass, and shall be confirmed or modified only with the approval of the Landscape Architect and Owner’s Representative upon review of soils tests. The following shall be regarded as the minimum allowable fertilization required.

1. Shrub Areas: Fertilize once per year.

3.3 **WATERING**

A. Water shall be applied to moisten the soil appropriately for the current seasonal climatic conditions. Avoid overwatering and creating areas of standing water, or under-watering and creating areas of dry soil.

B. Program watering for after 10:00 p.m. and before 7:00 a.m. and in conformance with Owner’s watering window requirements. Make frequent reviews of watering program, check soil moisture depth, and make full use of the versatility of the automatic controllers by making necessary adjustments in timing and frequency of watering to compensate for climatic changes and site conditions. The Contractor shall check all sprinkler heads weekly and repair or adjust all malfunctioning heads, as necessary, and to adjust program.

C. Groundcovers: Deep water as weather conditions require to provide adequate moisture for optimum growth. Lawns and groundcovers at no time shall show a lack of fresh green color or a loss of resilience due to lack of water.

D. Trees, Shrubs, Vines and Other Plant Materials: Water deeply and slowly to establish moisture to the depth of the root zone.

E. Watering shall be done in a manner to avoid erosion, excessive run-off ponding or creation of a water-logged soil condition.

3.5 **WEED AND PEST CONTROL**

A. Weed Control--All Areas: Keep free of weeds. Weeding may be done manually or by the use of selective weed killers. Extreme caution shall be observed if selective weed killers are used not to damage any other plants. Broadleaf herbicides shall be applied only with owner’s approval due to scheduling of the facility. Notification, including the use of signs, flags and barriers shall be provided in advance of the spray application, per Owner’s requirements.

B. Insects, Pest and Disease Control

1. Lawns, Trees, Shrubs, Groundcovers and Vines: Insects and diseases shall be controlled by the use of approved insecticides and fungicides.

2. Moles and gophers shall be controlled by traps, approved pellets inserted by probe gun, or other approved means.

3. Spray deciduous trees with dormant oil and fungicide during dormant periods only. Spray or treat evergreen trees, deciduous trees in leaf, and shrubs with specific insecticides and fungicides as a preventative measure as frequently as necessary to
control pest and diseases. Spray if problems develop, as often as required at the Owner's approval. Contractor to review problems with Owner as they develop and make recommendations for treating.

4. Snails and slugs shall be controlled by the use of an approved bait.

C. All plants shall be inspected on a regular basis, not to exceed 30-day intervals during the growing season, to determine the need for spraying. Spraying shall be required through diagnosis, and the control spray shall be of the type required and applied at the rate specified by the manufacturer.

D. Spraying for insect and disease control shall be done only by qualified trained personnel under the supervision of a State licensed pest control operator, using recognized and approved insecticides and fungicides. The spraying shall be done with extreme care to avoid any hazard to any person or pet in the area or adjacent areas, or any property damage. Contractor shall comply with owner’s requirements for notification of users and the public.

3.6 PRUNING

A. General: All pruning shall be done by qualified professional personnel using recognized and approved methods and techniques. Pruning shall be done by thinning and shaping to achieve a natural appearance. Excessive pruning or stubbing back will not be permitted. Do not remove lower branches of low branching or multi-trunk trees without consent of the Owner.

B. All cuts over 1 inch in diameter shall be painted with approved tree wound dressing. All pruning cuts shall be made flush. They shall be cleanly cut with no tearing of the bark. All dead or damaged branches shall be removed from the site.

C. Prune deciduous trees and vines when dormant to promote open framework in head. Prune evergreen trees in fall and early summer to thin out heads and shape. Prune shrubs annually by thinning and shaping only - **DO NOT SHEAR**. Remove all dead and damaged branches back to point of branching.

D. Where trees or shrubs occur in close proximity to walks or roads, prune to allow people and cars to move without interference from branches and foliage. Prune plants under roof overhangs to prevent scraping.

3.7 TREE STAKING AND GUYING

A. Maintain and replace stakes until plant is capable of standing vertical and free and able to resist normal high winds. Remove all stakes and guys at the conclusion of the maintenance period.

3.8 FIELD QUALITY CONTROL

A. Perform field inspections under provisions of Division 01 Specifications.

B. Coordinate field inspections with Sections 328400 "Landscape Irrigation", 329200 "Lawns and Grasses" and 329300 "Plants."
C. Owner and Landscape Architect Inspections: Inspections to confirm completion of the work of this Section may be performed at the discretion of the Owner at any time.

D. Contractor Performed Inspections: The contractor shall perform the following applicable inspections and provide written confirmation of completed and successful installation to the Owner and Landscape Architect.

2. Weed Abatement: Provide written certification of completion of weed abatement operations.

END OF SECTION 329301
SECTION 329500 – ILLUMINATION, TRAFFIC SIGNAL SYSTEMS AND ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Modifications to the City of Spokane General Special Provisions Section 8-20. (See Included)
SECTION 8-20  ILLUMINATION, TRAFFIC SIGNAL SYSTEMS AND ELECTRICAL

8-20.1 Description
(April 1, 2018  COS GSP)

Replace this section with the following:

This work consists of furnishing, installing and field testing all materials and equipment necessary to complete in place, fully functional system(s) of any or all of the following types including modifications to an existing system all in accordance with approved methods, the Plans, the Special Provisions, and these Specifications:

1. Traffic Signal System
2. Traffic Signal System Retrofit
3. Traffic Signal Conduit System
4. Illumination Conduit System
5. Illumination System
6. Intelligent Transportation System
7. Communication Conduit System
8. Communication Cables and Interfaces
9. Video & Data Transmission and Distribution System
10. Closed Circuit Television System
11. Permanent Variable Message Sign
12. Environmental Sensing Station
13. Non-Intrusive Vehicle Detector System
14. Temporary Traffic Signal System
15. Temporary Intersection Lighting System

8-20.2 Materials
(August 1, 2015  COS GSP)

Add the following after the first paragraph:

Communication Conduit shall meet the requirements of Section 9-29.1(4)A.

Crushed surfacing top course shall meet the requirements of Section 9-03.9(3).

The items provided in the appendices are provided for the convenience of the Contracting Agency and the Contractor, and is not guaranteed to be complete. The Contractor shall assume the responsibility for the making of estimates of size, kind, and quantity of materials included in the work to be done under the contract.
8-20.3 Construction Requirements

8-20.3(2) Excavating and Backfilling
(August 1, 2010 COS GSP)

Add the following:

Nonmetallic conduit installed by excavation shall be placed on a minimum 2-inch thick bed of sand. A minimum cover of 6-inches of sand shall be installed over the top of nonmetallic conduit installed by trenching.

8-20.3(4) Foundations
(December 19, 2016 COS GSP)

Replace the third paragraph with the following:

Foundations shall be poured in one pour unless otherwise directed by the Engineer.

When curb and/or sidewalk is to be installed adjacent to the foundation for a signal standard or luminaire standard, the Contractor shall install a CMP of the correct diameter at the foundation location to allow backfilling of the corner and establishment of proper curb grades prior to pouring the signal or lighting foundation. After establishment of the curb grade and prior to pouring the foundation, the CMP shall be cut 1 ft below final grade, and a strippable 1 foot tall form shall be rigidly installed and securely braced.

The foundation shall be poured to the bottom of sidewalk grade or lower.

Add the following after the ninth paragraph:

The Contractor shall furnish and install four 5/8” x 8” x 1-1/2” hot-dipped galvanized anchor bolts with nuts for mounting each controller cabinet.

Revise the thirteenth paragraph to read:

Both forms and ground which will be in contact with the concrete shall be thoroughly moistened before placing concrete; however, excess water in the foundation excavation will not be permitted.

Add the following after the last paragraph:

Whenever the edge of a concrete foundation extends within 18-inches of an existing or proposed concrete improvement, a slab with minimum thickness of 4-inches shall be extended to meet the existing improvement. The cost of such work shall be included in other items of construction.
Revise the first paragraph to read as follows:

The ends of all conduit, metallic and nonmetallic, shall be reamed to remove burrs and rough edges. Field cuts shall be made square and true. Malleable duct sealant shall be installed in the cabinet end of all cable vault-to-cabinet conduit that contains conductors and or cable. Mechanical plugs shall be installed in the cabinet end of all empty cable vault-to-cabinet conduit. The threaded ends of metal conduit shall be provided with approved conduit bushings and non-metal conduit shall be provided with end bells. Reducing couplings will not be permitted.

Revise the second sentence of the third paragraph to read as follows:

When conduit is installed for future use, as soon as the bushing or end bell has been installed and the sizing mandrel has been pulled through, the locate wire shall be installed and the cabinet end of the conduit shall be plugged.

Revise the second paragraph to read as follows:

Location Wire shall be installed with all nonmetallic conduit that contains fiber optic cable and all conduits identified to contain future fiber optic cable. Location Wire shall be installed inside the conduits. Location Wire shall extend 12-feet into boxes or vaults.

Delete the second paragraph

Delete the third paragraph beginning with “Foam Sealant”

Revise the fifth paragraph to read as follows:

Conduit runs, including outer-duct, which do not enter the traveled way or shoulders shall be Schedule 80 high-density polyethylene (HDPE) or Schedule 80 PVC.
Revise the second paragraph to read as follows:

PVC conduit ends shall be terminated with end bell bushings. PVC or HDPE conduit entering cable vaults and pull boxes shall be extended one inch inside the structure to allow innerduct to be secured.

8-20.3(5)C  Conduit Size
(March 1, 2014  COS GSP)

Revise the second sentence of the first paragraph to read as follows:

Conduits smaller than 2 inch electrical trade size shall not be used unless otherwise specified, except grounding conductors at service points may be enclosed in ¾ - inch-diameter conduit.

Delete the third paragraph.

8-20.3(5)E1  Open Trenching
(March 1, 2014  COS GSP)

Add the following after the last paragraph

When open trenching is allowed, trench construction shall conform to the City of Spokane’s Pavement Cut Policy.

Add after the last paragraph:

Flat pull tape shall be installed at the same time as conductors in the conduits. Locate wires are not considered conductors.

The minimum allowable radius of sweeps in communication conduit installation is 36-inches.

All PVC conduit installed shall be schedule 80.

One #14 AWG stranded THHN locator wire with orange insulation shall be placed in continuous lengths in empty conduits or where noted on the Plans.

8-20.3(6)  Junction Boxes, CableVaults, and Pull Boxes
(August 1, 2010  COS GSP)

Add the following after the first paragraph:

Junction boxes, cable vaults, and pull box details are shown in the COS Standard Plans in the ‘J’ series. Cable vaults and pull boxes shall include racking hardware as detailed. The precise location of the cable vaults, junction boxes, and pull boxes shall be
determined in the field by a representative from the Signal and Lighting Division depending upon conflicts with existing structures and utilities. Special care shall be taken during the placement of the junction boxes to avoid interference with other street items and utilities.

Conduit entering into a cable vault or pull box shall be located in the identical knock out location from the previous pull box or cable vault. Crossing of the conduit is not allowed.

Bell ends shall be placed on all conduits (do not glue in place). Openings around conduits shall be sealed and filled with grout to prevent water and debris from entering the vaults or pull boxes. The grout shall meet the specifications of the cable vaults and pull box manufacturers.

The Contractor shall provide and place a crushed base beneath the junction boxes, for an area the size of the junction box. The Contractor shall excavate to a 4-inch depth and install a compacted 4-inch depth of crushed surfacing top course material.

8-20.3(8) Wiring
(April 1, 2018 COS GSP)

Add the following after the first paragraph:

The copper communication (interconnect) cable shall be installed continuously without splices except where shown on the Plans. The required terminating and splicing of the communication (interconnect) cable will be performed by Contracting Agency forces.

The Contractor shall provide a re-enterable splice closure kit for each underground splice.

Replace the second paragraph with the following:

With the exception of induction loop circuits and illumination circuits, the wiring shall be run continuously, without splices, from a terminal located in a cabinet, compartment, pedestrian push button assembly, signal head, disconnect or luminaire head, to a similarly located terminal. Terminals located below ground are strictly prohibited. Illumination circuits shall be spliced in only the pole base at the hand hole.

Replace the third paragraph with the following:

Splices in underground induction loop circuits shall be made in junction boxes. Splices will be permitted only where shown in the plans or contract provisions. Induction loop circuits shall be spliced, soldered, crimped and isolated with an approved crimp-type connector prior to encapsulation.

Splices shall be enclosed in a rigid body re-enterable splice closure. Splice closures for induction loops shall be factory filled with encapsulant.
Delete the fourth paragraph and the conductor sequence color code chart.

Add the following at the end of the fifth paragraph:

Street Lighting Disconnect. A fused disconnect, GLR-10A, shall be installed in the luminaire circuits in each standard base according to 9-29.7.

Power over Ethernet (POE) Extender. Power over Ethernet extenders shall be located in the signal standard hand hole.

8-20.3(9)  Bonding, Grounding
(August 1, 2008 COS GSP)

Revise the eighth paragraph to read as follows:

The connection of the grounding electrode conductor(s) to grounding electrode(s) shall be made by the thermal-welding process.

8-20.3(10)  Services, Transformer, Intelligent Transportation System Cabinet
(November 1, 2012 COS GSP)

Add the following after the first paragraph:

The Contractor shall obtain the required electrical permits for installation of electrical service from the Contracting Agency’s Building Department. Permit fees shall be included in the unit contract price for the item of work requiring power.

The service shall be manufactured according to the details in the Standard Plans “J” series and meet industry code requirements. The Contractor shall make the necessary arrangements with the servicing utility to complete the service connection prior to the final inspection. A meter base is required unless otherwise specified.

Delete the second, and fifth paragraphs.

8-20.3(14)A  Signal Controllers
(October 1, 2017 COS GSP)
Add the following after the last paragraph:

The controller for this project shall be a Siemens M-60 controller.

8-20.3(14)C  Induction Loop Vehicle Detectors
(April 1, 2018 COS GSP)

Revise the title of Section 8-20.3(14)C to read as follows:
This Section is supplemented with the following:

The conductors that form the loop and terminate in a signal standard or junction box shall be joined to the loop lead-in cable as shown on the COS Standard Plans in the ‘J’ series. Where two or more loops are spliced to one lead-in cable, they will be spliced in series according to the direction of the City of Spokane Signals and Lighting Division Foreperson at 509-232-8801.

The shield in the loop lead-in cable shall not be connected or grounded.

Hot sealant installation shall be as follows:

1. Fill slot using the sealant manufacture’s installation procedure and approved equipment nozzle.
2. Fill slot within 1/8-inch of finished grade.
3. Do not overspill onto surface of pavement. Remove overspill excess immediately.

Cold sealant installation shall be as follows:

1. Fill slot using the sealant manufacturer's installation procedure and approved equipment nozzle.
2. Fill slot within 1/8-inch of finished grade.
3. Do not overspill onto surface of pavement. Remove overspill excess immediately.

Loop sealants shall be according to 9-29.100.

Loops shall be tested in accordance with Section 8-20.3(14)D prior to overlay at the splice location.

Loops shall be tested in accordance with Section 8-20.3(14)D after the overlay and prior to signal turn on at the cabinet.

The lead-in conduit or hose shall be installed in unpaved areas between the pavement and the junction box by trenching to a depth of 18-inches.

The lead-in shall be spliced to the two-conductor shielded cable in accordance with COS Standard Plans in the ‘J’ series.

The Contractor shall notify the Engineer when the traffic signal detectors are fully operable. The Engineer will then schedule the date and time for inspection and acceptance by the City of Spokane Signals and Lighting Division Foreperson at (509) 232-8801. The Contractor shall have a representative present during inspection and acceptance by the Engineer.
The Contractor shall furnish and install the materials necessary for the complete replacement of traffic signal detectors that are damaged due to the Contractor’s operations at the Contractor’s own expense.

Sawcut Induction Loops. The induction loops shall consist of a wire loop installed in saw cut slots according to the COS Standard Plans in the ‘J’ series.

No substitute shall be authorized for the types of conductors and insulations herein required, nor shall the loop location be altered by the Contractor without the permission or at the direction of the Engineer.

The loop wire shall be completely embedded in the sealant. The sawcuts for each loop shall be sealed the same working day that the loop wiring is installed.

The loops shall be tested prior to resurfacing in accordance with Section 8-20.3(14)D. A loop which fails testing after resurfacing shall be removed by grinding and then reinstalled in the pavement prior to resurfacing the pavement area. A loop that fails testing shall be replaced at no cost to the Contracting Agency.

8-20.3(14)E Signal Standards
(August 1, 2008  COS GSP)

Replace Item # 6 with the following:

6. Any damage to the galvanized pole surface shall be repaired with approved zinc rich paint.

8-20.3(14)X Traffic Signal Cabinets
(October 1, 2017  COS GSP)

Cabinets shall be completely wired and tested to the 2003 NEMA TS2 Traffic Controller Assemblies Specification with NTCIP Requirements Version 02.06 (as amended here in). In addition, and at a minimum, the following requirements shall be met:

The traffic signal cabinet for this project shall be a NEMA P TS2 Type 2 Cabinet.

NEMA Type P TS2-2

1 16 Position load bay TS2-2
1 Half Width Detector Rack wired for 1-BIU/16-channels of detection,
1 Half Width Detector Rack wired for 1-BIU/16 channels of detection/4
Channels of pre-emption
Auxiliary switch panel, detector panel (32 channel), fan thermostat
assemblies, power supply interface panel, power panel, video panel, final
assembly
1 Smart Monitor 16 channel MMU
The Contractor shall identify and mark each field wire in controller cabinets with PVC marking sleeves bearing the circuit number indicated in the Contract.

The Contractor shall identify and mark each field wire in controller cabinets with PVC marking sleeves bearing the circuit number indicated in the Contract.

Cables and conductors within the cabinet shall be routed and bundled together in such a manner as to present a neat appearance. Self-clinching nylon cable ties shall be used to securely bundle together cables and conductors. Cable ties shall be spaced not more than 12-inches apart nor closer than 6-inches, unless breakouts or routing dictates.

Cables and conductors for the traffic signal circuits, loop detectors, and telemetry circuits shall be routed to the front of the cabinet, then CLOCKWISE around the left side to beneath the appropriate termination point. The AC service and the luminaire wiring shall be routed to the front of the cabinet, then COUNTER-CLOCKWISE to the right side of the cabinet.

Service loops shall be provided whenever a conductor breaks away from a bundle and is terminated. The radius of the service loop shall be three times the diameter of #10 AWG or smaller conductors and 5 times the diameter of conductors larger than #10 AWG.

Terminating conductors shall terminate on the terminal block provided in the controller cabinet. Terminating conductors shall not be spliced together before termination on the terminal block. Terminating conductors shall end in either a solderless spade lug terminal or a high-pressure screw lug. If more than two conductors terminate on the same terminal screw, a high-pressure screw lug shall be used.

Solderless spade lug terminals shall be installed with a crimping tool matched to the terminal as recommended by the terminal manufacturer. The splicing tool shall be designated to prevent the dies from releasing the terminal until the proper compression has been completed.
High-pressure screw lugs, if used, shall have a cast copper body and work on screw and saddle principle. The saddle and cable socket shall be serrated. The saddle shall be of an overlapping design.

Luminaire splices within the controller cabinet shall be made by using insulated crimp-type splices and tape.

Spare conductors shall be taped and tied back.

Controller cabinets manufactured to current NEMA TS2 specifications shall provide for electrical isolation of AC neutral, equipment ground, and logic ground. Grounding conductors (signal commons) shall be terminated on the AC neutral bus. Bonding and equipment grounding conductors shall be terminated on the equipment ground bus. Logic commons (pedestrian push-button and detector unit commons) shall be terminated on the logic ground terminal(s) provided.

Controller cabinets and other concrete base mounted cabinets shall be installed on a bed of exterior-grade silicone caulking compound, white or clear in color, or approved equal sealant. The sealant bed shall cover the entire flange area of cabinet. A neat bead of the same sealant material shall be formed around both the exterior and interior perimeter of the cabinet-concrete joint after the cabinets are bolted down to form an effective watertight seal.

8-20.3(16) Reinstalling Salvaged Material

(August 1, 2008 COS GSP)

Add the following before the first paragraph:

The Contractor shall remove and legally dispose of the affected signal bases, foundations, controller bases, and the other non-salvageable signalization, communication equipment, and appurtenances as determined by the Engineer.

The Contractor shall also remove and preserve for salvage purposes the reusable signalization, communication, or interconnect equipment as determined by the Engineer. The Contractor shall exercise care when removing the reusable signalization, communication or interconnect equipment so as to maintain the reusable equipment’s serviceability. For the purposes of this Specification, “Salvage” means that the Contractor shall provide the salvage items to the Contracting Agency.

The Contractor shall arrange an on-site preconstruction field inspection with the Engineer and a representative of the Signal and Lighting Division to determine salvageability of the reusable signalization, communication, or interconnect equipment scheduled for removal within this contract.

The Contractor shall provide a written, itemized list of equipment, including the type, quantity, location and condition of signal items be salvaged, to the Engineer. The Engineer will forward the list to the Signal and Lighting Division Foreperson. The
Contractor shall provide this list to the Engineer at least 5 working days after the on-site preconstruction field inspection. Each item listed shall be delivered on a normal Contracting Agency workday to the City of Spokane Signal and Lighting Division warehouse located at 901 N. Nelson Street between the hours of 8:00 A.M. and 2:00 P.M. In order for the warehouse to prepare for the delivery of the items, the Contractor shall contact the Signal and Lighting Division Foreperson at (509) 232-8801 at least 2 City business days prior to the delivery date.

Upon delivery, the Contracting Agency will inspect and determine if each salvageable item is in an acceptable condition.

The Contractor shall replace in-kind, repair (to the Engineer's satisfaction) or pay the Contracting Agency to replace the salvageable and insitu signalization, communication, and interconnect equipment that is damaged due to the Contractor's operation, at no cost to the Contracting Agency.

Salvageable items not delivered to the City of Spokane Signal and Lighting Division warehouse by the Contractor by the end of the contract, shall be charged to the Contractor for full replacement cost or required to be replaced by the Contractor in-kind irrespective of its condition prior to removal.

If there was no on-site pre-construction field inspection prior to its removal, each salvageable items removed by the Contractor, delivered to the City of Spokane Signal and Lighting Division warehouse, and deemed not acceptable by the Contracting Agency, shall be charged to the Contractor for full replacement costs or be required to be replaced by the Contractor in-kind, irrespective of its condition prior to removal.

Preservation of Existing Materials to Remain. The Engineer may conduct a pre-acceptance and a post-acceptance inspection of each salvageable item within the limits of this contract.

**8-20.4 Measurement**  
(April 1, 2018 COS GSP)

Replace this Section in its entirety with the following:

All illumination system, signal system, intelligent transportation system, or other type of electrical system materials and performance of work called for in the plans will not be measured and shall be considered incidental to SCC TRANSIT CENTER Base Bid “B” of this contract.

**8-20.5 Payment**  
(April 1, 2018 COS GSP)
Replace this Section in its entirety with the following:

Payment will be incidental to SCC TRANSIT CENTER Base Bid “B”.

COS “Traffic Signal System, E Mission Ave and N Sycamore St” shall be considered incidental to SCC TRANSIT CENTER Base Bid “B” of this contract. This includes but is not limited to furnishing the tools, labor, equipment, and materials necessary to perform the work as specified, including the removal and legal disposal of the non-salvageable traffic signal equipment and appurtenances, removal and delivery of the salvageable signal equipment and appurtenances to the City of Spokane Signal and Lighting Division warehouse. The cost of street and sidewalk patching required by signalization and communication conduit are covered under Base Bid “B” of this contract.

Excavation, furnishing, and installing the crushed base material and compaction shall be considered incidental to the installation of the junction boxes and no separate payment will be made.

The Contractor, at own discretion, may substitute an equivalent concrete depth in place of the crushed surfacing top course but no additional payment will be made for such substitution.
END OF SECTION 329500
SECTION 329600 – ILLUMINATION, SIGNAL AND ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Modifications to the City of Spokane General Special Provisions Section 9-29. (See Included)
SECTION 9-29 ILLUMINATION, SIGNAL AND ELECTRICAL

9-29.1 Conduit, Innerduct, and Outerduct

9-29.1(4)A Rigid PVC Conduit
(March 1, 2014 COS GSP)

Rigid PVC Conduit shall be Schedule 80 for all locations, unless detailed otherwise in the plans.

9-29.1(5) Innerduct and Outerduct
(November 1, 2012 COS GSP)

Delete this section in its entirety.

9-29.1(5)A Rigid Galvanized Steel Outerduct with PVC or PE Innerduct
(April 6, 2009 COS GSP)

Delete this section in its entirety.

9-29.1(5)B Rigid PVC Outerduct with PVC or PE Innerduct
(April 6, 2009 COS GSP)

Delete this section in its entirety.

9-29.1(5)C Innerduct for Straight Sections of Galvanized Steel Outerduct or PVC Outerduct
(April 6, 2009 COS GSP)

Delete this section in its entirety.

9-29.1(5)D Conduit with Innerducts Fittings and Appurtenances
(April 6, 2009 COS GSP)

Delete this section in its entirety.

9-29.1(5)D1 Bends for 4-inch PVC Conduit with Innerducts or Galvanized Steel with Innerducts
(April 6, 2009 COS GSP)

Delete this section in its entirety.

9-29.1(5)D2 Prefabricated Fixed and Flexible Bends (for Innerducts)
(April 6, 2009 COS GSP)
Delete this section in its entirety.

Add the following new Subsection:

**9-29.1(100) MaxCell Innerduct**

(May 24, 2012 COS GSP)

MaxCell innerduct shall be of the size called out in the plans, contain the number of sleeves as called out in the plans, and be detectable by containing an 18 gauge solid copper core, green TFN insulated wire the entire length.

**9-29.2 Junction Boxes**

(November 1, 2012 COS GSP)

**9-29.2(1) Standard Duty and Heavy Duty Junction Boxes**

(November 1, 2012 COS GSP)

Delete the third paragraph beginning with “The Contractor shall provide shop drawings...”.

**9-29.2(1)A Standard Duty Junction Boxes**

(November 1, 2012 COS GSP)

Add the following to the first paragraph:

Type 7 junction boxes shall meet all the requirements of a type 8 junction box but shall be supplied without the locking bolt.

Revise the sixth paragraph, beginning with “Type 1, 2, and 8 non-concrete...” to read: Non-concrete junction boxes shall not be used.

**9-29.2(1)C Testing Requirements**

(November 1, 2012 COS GSP)

Delete Section 9-29.2(1)C Testing Requirements, in its entirety.

**9-29.2(2)A Standard Duty Cable Vaults and Pull Boxes**

(November 1, 2012 COS GSP)

Revise the first paragraph to read:

Standard Duty Cable Vaults and Pull Boxes shall be concrete and meet AASHTO M-199 or H-20 loading requirements.

**9-29.2(2)B Heavy Duty Cable Vaults and Pull Boxes**

(November 1, 2012 COS GSP)
Revise the first paragraph to read: Standard Duty Cable Vaults and Pull Boxes shall be concrete and meet AASHTO HS-20 loading requirements.

9-29.3 Fiber Optic Cable, Electrical Conductors, and Cable
(April 6, 2009 COS GSP)

9-29.3(1) Fiber Optic Cable
(October 11, 2017 COS GSP)

Add the following to this section:
Loose Buffered Cable
The fibers shall be placed in color coded loose buffer tubes in groups of **12**.

Tight Buffered Cable
Tight buffered cable shall contain single mode fiber optic fibers.
OFNR Rating.
Subcable assemblies containing individual tight buffered fibers shall consist of 3-millimeter diameter outer color coded jackets, aramid strength fibers, 900 micron color coded tight buffering, and acrylate fiber coating.
One acceptable alternate is the B-series breakout riser cable from Optical Cable Corporation with 3 millimeter diameter subcable jackets.

Pigtail Fiber Optic Cables
Pig tails shall contain single mode fiber optic fibers.
Pig tails shall be a 1 meter in length and be OFNR rated
Pig Tails shall contain factory terminated connectors and consist of subcables with a 2.8 to 3.0 millimeter diameter outer jackets, aramid strength fibers, 900 micron color coded tight buffering, and acrylate fiber coating.
Connectors shall match the type called for in the plans and be UPC polished.

9-29.3(2) Electrical Conductors and Cable
(November 1, 2012 COS GSP)

9-29.3(2)A Single Conductor
(November 1, 2012 COS GSP)

9-29.3(2)A1 Single Conductor Current Carrying
(November 1, 2012 COS GSP)

Replace this Section in its entirety with the following:
All current carrying single conductors shall be Type THWN, 600 V cable. Overhead service shall be Type THWN 600 V wire. Service conductors shall be copper of the size required by the Code.

9-29.3(2)A2 Grounding Electrode Conductor
(November 1, 2012 COS GSP)
Replace this Section in its entirety with the following:
Grounding electrode conductor shall be bare stranded copper.

9-29.3(2)A3 Equipment Grounding and Bonding Conductors
(March 1, 2014 COS GSP)

Replace this Section in its entirety with the following:
Equipment grounding and bonding jumpers shall be green insulated stranded copper with THHN 600 volt insulation of the size called out in the plans

9-29.3(2)B Multi-Conductor Cable
(March 1, 2014 COS GSP)

Replace this Section in its entirety with the following:
Two-conductor through 20-conductor unshielded signal control cable shall have stranded copper conductors and shall conform to the International Municipal Signal Association (IMSA) signal cable 20-1.

9-29.3(2)D Pole and Bracket
(March 1, 2014 COS GSP)

Add the following:
Luminaires calling for 30 foot mounting heights according to Standard Plan J-105, J-105B, and J-105C shall be Type UF two-conductor with ground, nonmetallic sheathed, 600 V. The wire size shall be #12 AWG unless otherwise specified.

9-29.3(2)I Twisted Pair Communication Cable
(November 1, 2012 COS GSP)

Replace this Section in its entirety with the following:
Twisted pair communication cable shall meet REA Specifications PE-39 for filled, data telephone cable. The conductors shall be #22 AWG, solid copper, twisted pairs. The twisted pairs shall be fully color coded. The shield shall be 8 mil aluminum, coated both sides with copolymer.

Add the following new Section:
9-29.3(2)ZZ Illumination Branch Cable
(March 1, 2014 COS GSP)

Illumination branch circuit cable shall be Type UF two-conductor with ground nonmetallic sheathed, 600 V cable. The wire size shall be #12 AWG unless otherwise specified.

Add the following new Section:
9-29.3(2)ZZA CCTV Power Cable
(April 1, 2018 COS GSP)
The power cable shall be outdoor rated and consist of three tinned copper stranded conductors of 14 AWG. The conductors shall be individually insulated and color coded. The cable insulation shall be rated at 300V.

Add the following new Section:
9-29.3(2) ZZB  Category 6 Cable
April 1, 2018 COS GSP)

Cat 6 cable shall be indoor/outdoor rated and contain 4 twisted pairs of 23 AWG solid bare copper conductors individually insulated and color coded according to TIA CAT 6 Standards. The cable shall contain 4 color coded 22 or 24 AWG solid twisted copper pairs, be non-shielded, and include a black UV resistant outer jacket.

Add the following new Section:
9-29.3(2) ZZC  Category 5e Cable
(August 9, 2018 COS GSP)

Cat 5e cable shall be outdoor rated, gel-filled, and contain 4 twisted pairs of 24 AWG solid bare copper conductors with shield and drain wire. Conductors shall be individually insulated and color coded according to TIA Cat 5e standards. The cable shall be tested to a minimum of 350 Mhz, and include a black UV resistant outer jacket.

Add the following new Section:
9-29.3(2) ZZD  Machine Vision Video Cable
(April 1, 2018 COS GSP)

With conventional Machine vision equipment the video cable shall meet RG-6/U specifications. The machine vision cable shall be BELDEN 1189A or equivalent.

Add the following new Section:
9-29.3(2) ZZE  GPS Preemption Cabling
(August 9, 2018 COS GSP)

The cable shall be Opticom Model 1070 GPS cable or meet the following:
The cable shall have a black SR-PVC outer jacket that is UV and moisture resistant.
The cable shall have a 90°C temperature rating.
The cable shall be rated for 300 volts.
The cable shall contain five twisted pairs of AWG #20 (7 x 28) stranded, individually tinned copper. The twisted pairs shall be Yellow/Yellow-Black; Blue/Blue-White; Orange/Orange-Green; Brown/Brown-White; Purple/Purple-White.
The cable shall contain an aluminized polyester shield.
The cable shall contain a drain wire of AWG #22 (7 x 28) stranded individually tinned copper.

9-29.6  Light and Signal Standards
(August 1, 2015 COS GSP)
Replace this Section in its entirety with the following:

Light and Signal Standard manufacturers shall be pre-approved by WSDOT. Light standards and signal standards (including Types 1, 2, 3, and 4) shall be in accordance with the details shown in the Plans, the City of Spokane Standard Plans J series, as specified in the Special Provisions, and as outlined herein. Fabrication of light and signal standards shall conform to the applicable requirements of Section 6-03.3(14).

Light and Signal Standard manufacturers shall provide full mill certification package upon delivery.
Traffic signal standards shall be supplied with mast arms, luminaire arm(s), anchor bolts and required bolts, nuts, and washers as shown on the Traffic Signal Standard Plans.

Poles shall be designed to meet 1994 AASHTO criteria and an 80 MPH sustainable wind loading.

Materials for steel light and signal standards, and associated anchorage and fastening hardware, shall conform to Sections 9-29.6(1), 9-29.6(2), and 9-29.6(5) unless otherwise specified in the steel light and signal standard fabricator’s shop drawing submittal, including supporting design calculations, as submitted in accordance with Sections 6-01.9 and 8-20.2(1) and the Special Provisions, and as approved by the Engineer.

Supplier shall furnish shop drawings and design calculations for approval if not pre-approved by the City of Spokane except Type I poles.

Anchor bolts for signal standards shall be delivered within thirty (30) days after receipt of order.

9-29.6(1) Steel Light and Signal Standards
(August 1, 2015 COS GSP)

Steel plates and shapes for light and signal standards shall conform to ASTM A 36, except that structural shapes may conform to ASTM A 992. Shafts for light and signal standards shall conform to ASTM A 572 Grade 50. Base plates for light standards shall conform to ASTM A 572, Grade 50. Base plates for signal standards shall conform to ASTM A 36. Connecting bolts shall conform to ASTM A 325. Fasteners for handhole covers, bands on lighting brackets, and connector attachment brackets shall conform to ASTM F 593.

The pole shaft shall be formed into a continuously tapered round shaft with a continuous uniform taper of approximately 0.14 inches per foot, with only one longitudinal welded seam, and no more than three (3) transverse welds for 30 foot poles. Standards with an outside diameter greater than 12 inches shall be round in shape but may be constructed as a multisided standard. Multisided standards shall have a
minimum of 12 sides which shall be convex and shall have a minimum bend radius of 4 inches.

The pole shaft shall be straight with a permissive not to exceed one (1) inch measured at the midpoint in place and unloaded. A maximum theoretical angular rotation of 1 degree, 40 minutes without wind load, will be permitted for poles and shall be measured with all signal heads, mast arms and luminaries in place.

The pole shaft shall contain a handhole with a reinforcing frame and cover. A second handhold shall be installed above the mast arm connection. See Standard Plan J-105b. The lower half of the handhole’s (at the base) reinforcing frame shall contain a 9/16 inch diameter hole tapped, with a stainless steel bolt and a stainless steel binding washer for connection of the grounding lug, for grounding purposes.

Signal Mast arms 50 feet and less in length shall be one piece. Signal Mast arm shall have an end cup and be formed into a continuously tapered round shaft.

Luminaire arms shall have a 2 inch tip tenon.

At a minimum, the pole shaft, mast arm(s), and luminaire arm(s) shall be designed to support 3-section traffic signal heads weighing 60 pounds and having 9.2 square feet of wind area, 5-section heads weighing 75 pounds and having 13.9 square feet of wind area and to support luminaries weighing 35 pounds and having 2.5 square feet of wind area. The location of the design load(s) are shown on the COS Standard Plans J Series. The Contract plans may contain additional heads or different attachment points above the minimums illustrated in the City Standard Plans to design. In this case, the standards shall be designed to support what is shown on the Plans.

Light and signal standards shall be hot-dip galvanized in accordance with AASHTO M 111 and AASHTO M 232. Steel used for light and signal standards shall have a controlled silicon content of either 0.00 to 0.04 percent or 0.15 to 0.25 percent. Mill test certificates verifying the silicon content of the steel shall be submitted to both the galvanizer and the Engineer prior to beginning galvanizing operations.

**9-29.6(4) Welding**  
(August 1, 2015  COS GSP)

Welding of steel structures shall be in accordance with AWS D1.1/D1.1M, latest edition, Structural Welding Code, and Section 6-03.3(25).

**9-29.6(5) Foundation Hardware**  
(August 1, 2015  COS GSP)

Anchor bolts shall be furnished with two nuts and two washers. Anchor bolts shall be hot-dipped galvanized for their entire length. Bolts shall be designed in accordance with
The ballast shall be capable of starting and operating one high pressure sodium lamp at the stated luminaire nominal voltage 60 Hz within the limits specified by the lamp manufacturer. The ballast including starting aid, must protect itself against normal lamp failure modes. The ballast shall be capable of operation with the lamp in an open or short circuit condition for 6 months without significant loss of ballast life.

The ballast shall be of the reactor type providing for a ± 5 percent input voltage range. The ballast design center will not vary more than 5 percent from rated lamp watts for nominal line voltage and nominal lamp voltage.

At any lamp voltage from nominal through life, lamp wattage regulation spread at that lamp voltage shall not exceed 2-1/2 percent or ± 1 line voltage variation.

The luminaire manufacturer will supply ballast electrical data and lamp operating volt-watt traces for nominal and ± 5 percent rated line voltage to verify ballast performance and compliance with lamp specifications, for the rated life of the lamp.

The ballast must reliably start and operate the lamp in ambient temperatures down to -30 degrees F for the rated life of the lamp.

The lamp current crest factor shall not exceed 1-1/2 for plus or minus ± 5 percent line voltage variation at any lamp voltage, from nominal through life. The power factor shall be 90 percent (nominal) or higher.

The ballast shall have a name plate attached permanently to the case, listing all electrical data.

**9-29.10 Luminaires**

**9-29.10(1) Cobra Head Luminaires**

(April 1, 2018  COS GSP)

Replace this Section in its entirety with the following:

A. All LED roadway luminaires shall be a Type III medium distribution with cutoff optics.
B. LED light sources shall produce a light color temperature of 4,000 K ± 300 K. The manufacturer shall submit fixture LM-79 and LM-80 reports in conjunction with the luminaire cut sheet. Light sources will also meet or exceed the following efficiency and longevity benchmarks:

**Light Emitting Diode (LED) Light Sources**

<table>
<thead>
<tr>
<th>Minimum Luminous Efficacy</th>
<th>Minimum Expected Lamp Life (hours)</th>
<th>Minimum Lumen Maintenance Factor (25°C) @ 50,000 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 lumens/Watt</td>
<td>&gt; 100,000</td>
<td>0.95</td>
</tr>
</tbody>
</table>

**BUG Rating (Maximum)**

| B: 2 | U: 0 | G: 2 |

C. LED Drivers (Drivers) shall be Class 1 or 2 type, adequately sized for the luminaires designed light output. The Driver shall be an integral part of the luminaire unit. It shall be a prewired, built-in type mounted in the luminaire.

Provide a manufacturer's nameplate on the Driver housing. The nameplate shall have the manufacturer's name, model number, serial number, hook-up diagram, power supply data, LED type and operating wattage.

The Driver shall operate the lamp within the limits specified below throughout the rated life of the lamp:

1. The LED light source shall not vary more than 10% in light output.

2. The LED light source wattage shall not vary more than plus or minus 5% of nominal when the LED light source is at its rated nominal.

3. The minimum efficiency of the Driver (nominal LED light source watts/line watts) shall not be less than 80%.

4. The Driver shall not allow the LED light source to extinguish when a line voltage dip between 40-50% occurs for several seconds.

5. The power factor shall not drop below 90% and the total harmonic distortion shall be less than 20% for the line voltage with allowable fluctuations of +/- 10%.

6. Drivers shall be provided with integral 10kV surge suppression.
7. The line starting current shall not exceed normal line operating current.

8. The Driver shall start and operate the LED light source in ambient temperatures down to -20 °F.

9. The Driver shall conform to all ANSI Standards.

Unless otherwise shown or specified, operate Drivers on a multi-voltage type to be connected to 120 V, 208 V, 240 V, or 277 V.

D. Furnish LED roadway luminaires for horizontal slip fitter end mounting.

Luminaires shall have cast aluminum housings and shall attach to 2 inch pipe tenons on mast arms. The luminaire attachment fitting shall provide for a minimum of plus or minus 3 degree adjustment of the luminaire in the vertical direction.

The lens and doorframe assembly, when closed, shall exert pressure against a gasket. Gaskets shall be composed of material capable of withstanding the temperatures encountered and shall be securely held in place.

All luminaires shall have their components secured to the luminaire frame with corrosion-resistant mounting hardware. The housing, complete with integral Driver, shall be weather tight, IP 66.

If sand-cast, the aluminum housing shall be left in its natural finish. If die-cast, the housing shall be given a coat of aluminum paint.

All traffic signal luminaires shall be Cobra head style, sized according to the illumination requirements of the roadway and energized by 120-240 V.

All Street Luminaires shall be Cobra head style, sized according to the illumination requirements of the roadway and energized by 120-240 V.

E. One of the following preapproved luminaire series shall be used, or approved equal:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>American Electric</td>
<td>Autobahn</td>
</tr>
<tr>
<td>Philips</td>
<td>Roadview</td>
</tr>
<tr>
<td>Cree</td>
<td>XSP</td>
</tr>
</tbody>
</table>

The fixture lumen output shall be as specified in the plans.
9-29.11 Control Equipment
(August 9, 2018  COS GSP)

Replace this Section in its entirety with the following:

Each luminaire shall be controlled by plug-in photoelectric control mounted on the luminaire housing.

9-29.11(2) Photoelectric Controls
(August 1, 2008  COS GSP)

Supplement this Section with the following:

The photoelectric control shall be a plug-in device, rated to operate on 120-240 volts, 60 Hz. The unit shall consist of a light sensitive element connected to necessary control relays. The light sensitive element shall have a spectral response such that it is especially sensitive to north sky illumination.

The unit shall be so designed that a failure of any electronic component will energize the lighting circuits.

The control shall be protected by a lightning arrester to provide surge protection to a minimum of 10,000 amperes and shall be rated to switch on 1,000 watts incandescent.

The photoelectric receptacle shall be in accordance with EEI-NEMA Standards.

9-29.12 Electrical Splice Materials

9-29.12(1) Illumination Circuit Splices
(April 1, 2018  COS GSP)

Replace this Section in its entirety with the following:
Illumination circuit splices shall be either, wirenuts or solderless crimped connections to securely join the wires, both mechanically and electrically, as defined in 8-20.3(8). Splices shall be made in the pole base at the hand hole.

9-29.12(2) Traffic Signal Splice Material
(August 9, 2018  COS GSP)

Replace this Section in its entirety with the following:

Lead-in cable to loop wire or magnetometer sensing probe splices shall be rigid body, re-enterable type with encapsulating gel sealant.

Copper communication cable splices shall be housed in a 3M Better Buried 2” x 24” with 4441 encapsulate splice case or approved equal.
Add the following:

**Controller Unit (CU)**

**Siemens M60 Controller**
The controller unit shall exceed the requirements of Advanced Traffic Controller (ATC) standard v5.2b., published 2006. The controller shall run on a Linux operating system and shall be configurable as a local, master or local/master depending on the local intersection software in use. The controller shall have a removable light-emitting diode backlit LCD Display with 16 lines of 40 characters with adjustable contrast setting front panel. It shall have a 37 pin D connector for backward compatibility with TS-1 facilities. The following port configurations are required:

Central Processor Unit (CPU)
- Open architecture platform with standard Linux operating system
- MPC 8270 266MHz processor
- 512MB FLASH, 64MB DRAM and 1MB SRAM
- TOD Clock with automatic daylight savings time adjustment
- Power supply will power the SRAM during power failures

Keyboard and Display
- Siemens Multiview Display with dual view screens
- Removable light-emitting diode backlit LCD Display with 16 lines of 40 characters with adjustable contrast setting
- Emulation of terminal per Joint NEMA/AASHTO/ITE Standard
- Key quantity and function per Joint NEMA/AASHTO/ITE Standard

Communications Module
- 10 Base-T Ethernet with built-in switch and 5 front panel
- 4 RJ-45 connectors
- 4 USB 2.0 Ports and a Datakey Port
- Dedicated GPS Port
- Unique MAC address assigned by the Institute of Electrical and Electronic Engineers (IEEE)
- EIA-232 port for uploading/downloading applications software and OS updating
- Single and multi-mode fiber optic options
- 1200 bps Frequency Shift Keying (FSK) modem (optional)

Controller Housing
- 7 expansion slots with card guides for standard size Versa Modules and 2 slots with card guides for standard Joint
- NEMA/AASHTO.ITE ATC modems (optional)
- Polycarbonate construction (excluding back panel), rear mounting tabs and aluminum power supply mounting plate for electrical grounding
• Carrying handle

**9-29.13(4) Traffic Signal Controller Software**  
(April 1, 2018  COS GSP)

Add the following:

The Siemens M60 controller shall come with the most current SEPAC Version of local intersection software and shall be operable with the TACTICS™ regional software platform.

**9-29.13(5) Flashing Operations**  
(April 1, 2018  COS GSP)

Add the following:

All P size cabinets shall be wired to flash for all channels. Flashing operation shall alternate between the used vehicle phases 1,3,5,7 and 2,4,6,8. Flash programming shall be either red or yellow simply by changing wires on the front of the load-bay.

All M size cabinets shall be wired to flash for all channels. Flashing operation shall alternate between the used vehicle phases 2,6 and 4,8. Flash programming shall be either red or yellow simply by changing wires on the front of the load-bay.

**9-29.13(6) Emergency Preemption**  
(April 1, 2018  COS GSP)

Add the following:

The Emergency vehicle preemption system shall utilize Global Positioning System technology to provide active vehicle preemption based on an estimated arrival time or distance to the signal.

**9-29.13(8) Generator Transfer Switch**  
(February 1, 2016  COS GSP)

Replace this Section in its entirety with the following:

The cabinet front door shall have a locking generator bypass compartment that shall be used to connect a generator to operate the cabinet during extended loss of service line power. The generator compartment shall be capable of being closed and locked while a generator is connected. The mechanism for allowing generator cable access while the compartment is closed, shall be an integral part of the generator bypass door, via a sliding panel that will normally be in the closed position. Inside the compartment there shall be a silkscreened panel housing a Hubbell HBL2615 30A / 125V flanged inlet receptacle capable of accepting a standard generator plug, a BACO HC52DQG cam
switch with split AC+ feeds, and (2) LED lamps with sockets. One LED shall be illuminated when the cabinet has service line power and the other when the cabinet is under generator control. All LED’s shall be field replaceable without putting the intersection in flash and shall carry a 5 year manufacturer warranty.

All wiring to the generator bypass compartment shall be contained in a single cable bundle. The cable shall connect to the backside of the electrical components and shall only be accessible from the inside of the cabinet front door. All electrical components on the inside of the front door that carry AC voltage shall be covered by a see-through plexiglass cover. The generator bypass cable shall terminate at the same power panel location as service line voltage.

**9-29.13(10)A Auxiliary Equipment for NEMA Controllers**

*(June 21, 2018  COS GSP)*

Replace this Section in its entirety with the following:

Auxiliary Equipment shall meet NEMA TS2 Type 2 standards.

**Auxiliary Panel**
The cabinet shall include an auxiliary switch panel mounted to the interior side of the police panel compartment on the cabinet door. This panel shall be hinged at the bottom to allow access to the soldered switches with the use of clamps or tools. Both sides of the panel shall be silkscreened. All of the switches shall be protected by a hinged see-through Plexiglas cover.

At a minimum the following switches shall be included;

**Controller ON/OFF Switch:** There shall be a switch that renders the controller and load-switching devices electrically dead while maintaining flashing operations for purpose of changing the controller or load-switching devices. The switch shall be a general-purpose bat style toggle switch with .688-inch long bat.

**Signals ON/OFF Switch:** There shall be a switch that renders the field signal displays electrically dead while maintaining controller operation for purpose of monitoring controller operations. The switch shall be a general-purpose bat style toggle switch with .688-inch long bat.

**Stop Time Switch:** There shall be a 3-position switch labeled “Normal” (up), “Off” (center), and “On” (down). With the switch in the “Normal” position, a stop timing command shall be applied to the controller by the police flash switch or the MMU (Malfunction Management Unit). When the switch is in its “Off” position, stop timing commands shall be removed from the controller. The “On” position shall cause the controller to stop time. The switch shall be a general-purpose bat style toggle switch with .688-inch long bat.
**Technician Flash Switch:** There shall be a switch that places the field signal displays in flashing operation while the controller continues to operate. This flash shall have no effect on the operation of the controller or MMU. The switch shall be a general-purpose bat style toggle switch with .688-inch long bat.

**Pedestrian Test Switches:** There shall be (4) disconnect/test switches for the pedestrian phases. These switches shall have three positions labeled “On” (up) which shall be normal operation, “Off” (center) which shall disconnect the applicable pedestrian phase, and “Test” (down) which shall provide a true input to the controller for the applicable pedestrian phase. These switches shall be labeled 2, 4, 6 and 8.

**Pre-Empt Test Switches:** All (6) preempt inputs shall have disconnect/test switches. These switches shall have two positions labeled “On” (up) which shall connect the controller to the Opticom output, and “Test” (down) which shall provide a momentary true input to the controller. These switches shall be labeled 1, 2, 3, 4, 5 and 6.

**Police Panel**
When specified to include the police panel:
Behind the police door the following switch shall be included;

**Flash Switch:** There shall be a switch for the police that puts the cabinet into flashing operations. The switch shall have two positions, “Auto” (up) and “Flash” (down). The “Auto” position shall allow normal signal operation. The “Flash” position shall immediately cause all signal displays to flash as programmed for emergency flash and apply stop time to the controller. When the police flash switch is returned to “Auto”, the controller shall restart except when the MMU has commanded flash operation. The switch shall be a general-purpose bat style toggle switch with .688-inch long bat.

**Cables**
All wire cable bundles shall be encased in flex or expandable braided sleeving along their entire free length.

SDLC cables shall be professionally routed in the cabinet interior to easily reach the controller, malfunction management unit or detector racks. SDLC connectors shall be secured with screws. Spring clips shall not be used.

**Detector Racks**
NEMA P Cabinet and NEMA P Plus Cabinet
The cabinet shall have 32 channels of detection within two (2) ½ width detector racks. One (1) ½ width rack shall support sixteen (16) channels of loop detection using four (4) slots with four (4) channels per slot, one (1) EDI BIU700H Bus Interface Unit (BIU) and one (1) 764 Opticom™ phase selector(s). One ½ width rack shall support sixteen (16) channels of loop detection using four (4) slots with four (4) channels per slot and one (1) EDI BIU700H Bus Interface Unit (BIU). The two (2) racks will be mounted, one on top of the other, on the uppermost shelf within the cabinet. The power and loop cabling shall be connected via a 37 pin DB connector using spring clips. The Opticom cable shall be connected via a 24 pin connector. The power cable shall be a 6 pin
connector. All power wires shall be 18AWG. The addressing of detector rack shall be accomplished via dipswitches mounted to the PCB. There shall be the capability to turn off the TS2 status to the BIU for the uses of TS1 detector equipment via dipswitches mounted to the PCB. There shall be a 34 pin connector using locking latches that breaks the output from the detector to the input of the BIU, there shall also be +24VDC and logic ground on this connector. The rack shall have space at the bottom front for labeling.

Detector Panel
The detector panel shall support (32) channels of vehicle detection, (4) channels of emergency vehicle preemption, and (4) channels of pedestrian detection on a single panel. This panel will be mounted on the left side of the cabinet below the bottom shelf. The panel shall also include (19) position neutral and ground buss bars with raised slotted & torque style screw head.

Video Detection Panel
When video detection is specified there shall be video detection interface panel for single point interface for video power and coax cabling. The panel shall provide up to six (6) individual surge arrestor and circuit breaker circuits so that individual cameras can be replaced in the field without disrupting the entire video detection system.

Supplemental Loads
If specified, all pedestrian phase yellows and odd numbered vehicle phase yellows and greens shall be loaded with a 2.5K-ohm, 10-watt resistor. Each load resistor shall be easily accessed from the back of the main panel (load-bay).

Service Surge Suppression
The cabinet shall be equipped with an EDCO model SHP300-10 or approved equivalent surge arrestor mounted on the power panel. Power to all cabinet electronics shall come through this surge suppression circuit.

Power Panel
The power panel shall handle all the power distribution and protection for the cabinet and shall be mounted in the bottom right side of the facility. All equipment shall be mounted on a 12” x 17” silkscreened aluminum panel and include at a minimum the following equipment:

- A 30-amp main breaker shall supply power to the load bay, load switches and auxiliary panel.
- A 20-amp auxiliary breaker shall supply power to the fan, light and GFI.
- A 20-amp equipment breaker shall supply power to the controller, MMU, power supply and convenience outlet and/or power strip.
- A 50-amp, 125 VAC radio interference line filter.
- An EDCO model SHP300-10 surge arrestor.
- A normally open, 50-amp, solid-state relay. The relay shall have a green LED light that is on when energized. (No Mercury Contactors shall be allowed)
- One see-through Plexiglas cover on stand-offs to protect maintenance personnel from AC line voltages. This shall be removable by loosening screws but without removing screws.
- Two (19) position solid aluminum, tin plated neutral buss bar with raised slotted & torque style screw heads.
- One (19) position solid aluminum, tin plated ground buss bar with raised slotted & torque style screw heads.
- Two MOVs shall be terminated on the 120AC in field terminal. One tied between line and ground, the other between neutral and ground.

**Malfunction Management Unit (MMU)**
The cabinet shall come with an (MMU) that meets all the requirements of NEMA TS2-2003 while remaining downward compatible with NEMA TS1. It shall have (2) high contrast LCD displays and an internal diagnostic wizard. It shall come with a 10/100 Ethernet port. It shall come with software to run flashing yellow arrow operation. The MMU shall be an Eberle Design, Inc. model MMU-16LEip or approved equivalent.

**Load Switch**
The cabinet shall come with (9 (nine) for M Cabinet or 16 for P Cabinet) load switches. All load switches shall be cube type and have LED indications for both the input and output side of the load. The load switches shall be PDC model SSS87I/O or approved equivalent.

**Flasher**
The cabinet shall come with (1) flasher. The flasher shall be cube type and have LED indications. The flasher shall be PDC model SSF87 or approved equivalent.

**Flasher Transfer Relay**
The cabinet shall come with (3 (three) for M Cabinet or 6 for P Cabinet) heavy duty flash transfer relays. The relays shall be Detrol Controls model 295 or approved equivalent.

**Bus Interface Unit (BIU)**
The cabinet shall come with (3 for M Cabinet and 2 for P Cabinet) bus interface units (BIU). These shall meet all the requirements of NEMA TS-2 1998 standards. In addition, all BIUs shall provide separate front panel indicator LED's for DC power status and SDLC Port 1 transmit and receive status. The (BIU)'s shall be Eberle Design, Inc. model BIU700H or approved equivalent.

**Power Supply (PS)**
The cabinet shall come with a shelf mounted cabinet power supply meeting at minimum TS 2-2003 standards. It shall be a heavy duty device that provides +12VDC at 5 Amps / +24VDC at 2 Amps / 12VAC at .25 Amp, and line frequency reference at 50 mA. The power supply shall provide a separate front panel indicator LED for each of the four outputs. Front panel banana jack test points for 24VDC and logic ground shall also be provided. The power supply shall provide 5A of power and be able to cover the load of four (4) complete detector racks. The (PS) shall be Eberle Design, Inc. model PS250 or approved equivalent.
**Loop Amplifiers**
The cabinet shall come with (4 for M Cabinet and 8 for P Cabinet) 4-channel rack mounted loop amplifiers. These devices shall have LCD displays and be capable of monitoring the call strength from all (4) channels (2 at a time) via a pie graph on the front panel. These devices must have the capability to perform directional logic and 3rd car queuing for protected/permissive operation. The loop amplifiers shall be Eberle Design, Inc. model ORACLE4H or approved equivalent.

**Opticom™**
The cabinet shall come with (1) 4-channel rack mounted Opticom phase selector. The Opticom phase selectors shall be Global Traffic Technologies model 764 or approved equivalent.

**BBS System**
When specified for inclusion, the uninterruptable power system (BBS) shall include at a minimum a UPS module with SNMP, ATS assembly, batteries, battery heater mats, battery cables and a battery management system. All other ancillary equipment for a complete functioning UPS system shall be included. The BBS shall be located in a separate compartment with a separate external door equipped with one door switch to report door open status. The door shall be mounted with a single continuous stainless steel piano hinge that runs the length of the door.

The key BBS system components include:

**UPS Module**
The cabinet UPS module shall be (1) FXM 2000W uninterruptible power supply that supplies clean reliable power control and management. It shall have Automatic Voltage Regulation (AVR), an Ethernet SNMP interface and a control and power connection panel that is rotatable for viewing in any vertical or horizontal orientation. It shall have nominal dimensions of 5.22” x 15.5” x 8.75” and come with mounting brackets. The UPS module shall be an Alpha model 017-232-29 or equivalent.

**UATS/UGTS Assembly**
The UPS cabinet shall contain a universal automatic transfer switch and universal generator transfer switch connected between the UPS module and the batteries. It shall have surge protection, have dimensions of 3.25” x 15.5” x 6.00” and come with mounting brackets. The ATS module shall be an Alpha model 020-168-21 or equivalent.

**UPS Batteries**
The batteries shall be (4) high performance silver alloy sealed valve regulated lead acid AlphaCell™ GXL GelCell batteries with 109Ah runtime. The BBS batteries shall be Alpha model 220 GXL or equivalent.

**UPS Battery Harness**
The UPS battery harness shall be a battery cable (5) foot long wired for (4) batteries. The battery harness shall be Alpha model 740-628-27 or equivalent.
**Battery Management System**
The battery management system shall be AlphaGuard™ battery charge management system which extends battery operational life. It shall be an Alpha model 012-306-21 or equivalent.

**9-29.13(10)C NEMA Controller Cabinets**
*(August 1, 2015 COS GSP)*

**Replace** this Section in its entirety with the following:

Each NEMA traffic controller shall be housed in a weatherproof cabinet conforming to the following requirements:

The cabinet shall be a completely wired and tested to the most current NEMA TS2-2003 v02.06 Type 2 Traffic Controller Assemblies Specification with NTCIP Requirements Version 02.06 (as amended here in). In addition, and at a minimum the following requirements shall be met:

The P cabinet shall be designed for 16 channel operation where load switch sockets 1-8 will be configured for a vehicle phase, load switch sockets 9-12 will be pedestrian phase and load switch sockets 13-16 will be overlaps A-D. These load switch sockets shall be configured in this manor without rewiring the back side of the load-bay.

The M cabinet shall be designed for 9 channel operation. Load switches 1-4 shall be vehicle phases 2,4,6,8; load switches 5-8 shall be pedestrian phases 2,4,6,8; load switch 9 shall be Overlap A. These load switch sockets shall be configured in this manor without rewiring the back side of the load-bay.

The cabinet shall be wired for (16 for M or 32 for P) channels of detection.

The cabinet shall be capable of integrating transit signal priority equipment.

The use of PC boards shall not be allowed except in detector racks or BIU cages.

The use of plug and play modules shall not be allowed.

All cabinet 120VAC wires shall be 18AWG or greater, including controller “A, B, & C” and MMU “A & B” cables.

The entire cabinet and components shall undergo a 72 hour test burn in before delivery to the testing agency. If the cabinet comes with a controller, the cabinet shall come with an ATSI TS2 Frame grabber communications test report before delivery will be accepted.

The cabinet shall meet “Buy America” specifications.

The cabinet assembly shall be completely manufactured in the United States of America.
Cabinet Enclosure
At a minimum the P cabinet shall meet the following criteria:

1. It shall have nominal dimensions of 56” high x 44” width x 25.5” depth and meet the footprint dimensions as specified in Section 7.3 of NEMA standards for a Type P cabinet. The cabinet base shall have continuously welded interior mounting reinforcement plates with the same anchor bolt hole pattern as the footprint dimensions.

2. Shall be fabricated from 5052-H32 0.125-inch thick aluminum.

3. The cabinet shall be double-flanged where it meets the cabinet door.

4. The top of the cabinet shall be sloped 1” towards the rear to facilitate water runoff. And shall bend at a 90° angle at the front of the cabinet. Lesser slope angles are not allowed.

5. The inside of the cabinet shall utilize C channel rails. (2) Welded on the back wall on 34” center and (4) welded on each side wall on 08” center with 04” between sets. C channel rails shall be 48” in length, start 5” from the bottom of the cabinet interior and run the entire usable height the cabinet side walls. Adjustable rails are not allowed.

6. The Cabinet shall be supplied with a natural mill finish inside and out, unless otherwise specified.

7. All external fasteners shall be stainless steel. Pop rivets shall not be allowed on any external surface.

8. The cabinet shall be supplied without a door handle. The door shall incorporate a 3/8” Allen head socket recessed in the cabinet door. The cabinet shall be supplied with (1) 3/8” removable Allen head wrench.

9. When the police panel is specified for inclusion, the main door shall contain a police door with a conventional police lock. A key shall be provided for both the cabinet lock and the police door lock. The police door shall be recessed into the main door so that the police door is flush with the main door.

10. A closed-cell, neoprene gasket seal shall be bonded to all enclosure doors. A stiffener plate shall be welded across the width of the inside of the main door to prevent flexing. A main door bar stop shall be a two-position, three-point stop that accommodates open-angles at 90, 125, and 150 degrees. A louvered air entrance located at the bottom of the main door shall satisfy NEMA rod entry test requirements for 3R ventilated enclosures. Bearing rollers shall be applied to ends of door latches to discourage metal-on-metal surfaces from rubbing. Lock assembly shall be positioned so handle does not cause interference with key when opening the door.

11. When the police panel is specified for omission, the police panel door and all associated appurtenances shall be omitted.
12. The cabinet shall be equipped with a universal lock bracket capable of accepting a Best™ Construction Core and a Corbin#2 tumbler series lock. The cabinet shall come equipped with a Best blue construction core lock.

13. The cabinet shall be supplied with two door switches which control the door open status and the cabinet interior lighting circuits.

14. All exterior seams shall be manufactured with neatly formed continuously weld construction. The weld for the police box door shall be done on the inside of the cabinet door. All welds shall be free from burrs, cracks, blowholes or other irregularities.

15. The fan baffle panel seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet.

16. The cabinet shall be UL listed

17. The cabinet shall come with lifting ears affixed to the upper exterior of the cabinet. These ears shall utilize only one bolt for easy reorientation.

18. The cabinet shall be supplied with a three-stage, multi-ply progressive density polyester, disposable air filter. Filter element shall be attached with Velcro type mounting along the full length of all four edges. Filter performance UL 900 Class 2 listed and shall conform to ASHRAE Standard 52.1.

19. The door shall be mounted with a single continuous stainless steel piano hinge that runs the length of the door. Attaching tamper resistant bolts shall also be stainless steel.

At a minimum the P-Plus cabinet shall meet the following criteria:

1. The cabinet shall have nominal dimensions of 56” high x 44” width x 25.5” depth and meet the footprint dimensions as specified in Section 7.3 of NEMA standards for a Type P cabinet. The cabinet base shall have continuously welded interior mounting reinforcement plates with the same anchor bolt hole pattern as the footprint dimensions shown in Standard Plan J-106b.

2. The cabinet shall be fabricated from 5052-H32 0.125-inch thick aluminum.

3. The cabinet shall be double-flanged where it meets the cabinet doors.

4. The top of the cabinet shall be sloped 1” towards the rear to facilitate water runoff. And shall bend at a 90° angle at the front of the cabinet. Lesser slope angles are not allowed.

5. The inside of the cabinet shall utilize “C” channel rails. (2) Welded on the back wall on 34” center and (4) welded on each side wall on 8” center with 4” between sets. “C” channel rails shall be 48” in length, start 5” from the bottom of the cabinet interior and run the entire usable height the cabinet side walls. Adjustable rails are not allowed.

6. The cabinet shall be supplied with a natural mill finish inside and outside.
7. All external fasteners shall be stainless steel. Pop rivets are not be allowed on any external surface.

8. The cabinet shall be supplied without door handles. The doors shall incorporate a 3/8” Allen head socket recessed in the cabinet door. The cabinet shall be supplied with (1) 3/8” removable Allen head wrench

9. When the police panel is specified for inclusion, the main door shall contain a police door with a conventional police lock. A key shall be provided for both the cabinet lock and the police door lock. The police door shall be recessed into the main door so that the police door is flush with the main door.

10. A closed-cell, neoprene gasket seal shall be bonded to all enclosure doors. A stiffener plate shall be welded across the width of the inside of the main door to prevent flexing. The main door and the battery compartment door bar stops shall be a two-position, three-point stop that accommodates open-angles at 90, 125, and 150 degrees. A louvered air entrance located at the bottom of the each door shall satisfy NEMA rod entry test requirements for 3R ventilated enclosures. Bearing rollers shall be applied to ends of door latches to discourage metal-on-metal surfaces from rubbing. Lock assemblies shall be positioned so handle does not cause interference with key when opening the doors.

11. When the police panel is not specified for omission, the police panel door and all associated appurtenances shall be omitted.

12. The cabinet shall be equipped with universal lock brackets capable of accepting a Best™ Construction Core and a Corbin#2 tumbler series locks. The cabinet shall come equipped with a Best blue construction core locks.

13. The cabinet shall be supplied with three door switches which control the door open status of both doors and the cabinet interior lighting circuits.

14. All exterior seams shall be manufactured with neatly formed continuously welded construction. The weld for the police box door shall be done on the inside of the cabinet door. All welds shall be free from burrs, cracks, blowholes or other irregularities.

15. The fan baffle panel seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet.

16. The cabinet shall be UL listed.

17. The cabinet shall be supplied with lifting ears affixed to the upper exterior of the cabinet. These ears shall utilize only one bolt for easy reorientation.

18. The cabinet shall be supplied with a two-stage, multi-ply progressive density polyester, disposable air filter. Filter element shall be attached with Velcro type mounting on all four edges. Filter performance UL 900 Class 2 listed and shall conform to ASHRAE Standard 52.1. The filter element shall be attached with Velcro type mounting along the full length of all four edges.
19. The doors shall be mounted with a single continuous stainless steel piano hinge that runs the length of the door. Attaching tamper resistant bolts shall also be stainless steel.

Generator Bypass Compartment and Cable
The cabinet front door shall have a locking generator bypass compartment that shall be used to connect a generator to operate the cabinet during extended loss of service line power. The generator compartment shall be capable of being closed and locked while a generator is connected. The mechanism for allowing generator cable access while the compartment is closed, shall be an integral part of the generator bypass door, via a sliding panel that will normally be in the closed position. Inside the compartment there shall be a silkscreened panel housing a Hubbell HBL2615 30A / 125V flanged inlet receptacle capable of accepting a standard generator plug, a BACO HC52DQG cam switch with split AC+ feeds, and (2) LED lamps with sockets. One LED shall be illuminated when the cabinet has service line power and the other when the cabinet is under generator control. All LED’s shall be field replaceable without putting the intersection in flash and shall carry a 5 year manufacturer warranty.

All wiring to the generator bypass compartment shall be contained in a single cable bundle. The cable shall connect to the backside of the electrical components and shall only be accessible from the inside of the cabinet front door. All electrical components on the inside of the front door that carry AC voltage shall be covered by a see-through plexiglass cover. The generator bypass cable shall terminate at the same power panel location as service line voltage.

At a minimum the M cabinet shall meet the following criteria:

1. It shall have nominal dimensions of 51” high x 30” width x 16” depth and meet the footprint dimensions as specified in Section 7.3, Table 7-1 of NEMA TS2 standards for a Type M cabinet. The cabinet base shall have continuously welded interior mounting reinforcement plates with the same anchor bolt hole pattern as the footprint dimensions.
2. Shall be fabricated from 5052-H32 0.125-inch thick aluminum.
3. The cabinet shall be double-flanged where it meets the cabinet door.
4. The top of the cabinet shall be sloped 1” towards the rear to facilitate water runoff. And shall bend at a 90° angle at the front of the cabinet. Lesser slope angles are not allowed.
5. The inside of the cabinet shall utilize C channel rails. (2) Welded on the back wall on 20” center and (2) welded on each side wall on 08” center. The C channel rails on the back and side walls shall be 41” in length. The C channel rail on the back wall shall start 3” from the bottom of the cabinet interior. The C channel rails on the side walls shall start 2” from the bottom of the cabinet interior. Adjustable rails are not allowed.
6. The Cabinet shall be supplied with a natural mill finish inside and out, unless otherwise specified.

7. All external fasteners shall be stainless steel. Pop rivets shall not be allowed on any external surface.

8. The cabinet shall be supplied without a door handle. The door shall incorporate a 3/8” Allen head socket recessed in the cabinet door. The cabinet shall be supplied with (1) 3/8 removable Allen head wrench.

9. When the police panel is specified for inclusion, the main door shall contain a police door with a conventional police lock. A key shall be provided for both the cabinet lock and the police door lock. The police door shall be recessed into the main door so that the police door is flush with the main door.

10. A closed-cell, neoprene gasket seal shall be bonded to enclosure doors. A stiffener plate shall be welded across the width of the inside of the main door to prevent flexing. A main door bar stop shall be a two-position, three-point stop that accommodates open-angles at 90, 125, and 150 degrees. A louvered air entrance located at the bottom of the main door shall satisfy NEMA rod entry test requirements for 3R ventilated enclosures. Bearing rollers shall be applied to ends of door latches to discourage metal-on-metal surfaces from rubbing. Lock assembly shall be positioned so handle does not cause interference with key when opening the door.

11. When the police panel is specified for omission, the police panel door and all associated appurtenances shall be omitted.

12. The cabinet shall be equipped with a universal lock bracket capable of accepting a Best™ Construction Core and a Corbin#2 tumbler series lock. The cabinet shall come equipped with a Best blue construction core lock.

13. The cabinet shall be supplied with two door switches which control the door open status and the cabinet interior lighting circuits.

14. All exterior seams shall be manufactured with a neatly formed continuously weld construction. The weld for the police box door shall be done on the inside of the cabinet door. All welds shall be free from burrs, cracks, blowholes or other irregularities.

15. The fan baffle panel seams shall be sealed with RTV sealant or equivalent material on the interior of the cabinet.

16. The cabinet shall be UL listed.

17. The cabinet shall come with lifting ears affixed to the upper exterior of the cabinet. These ears shall utilize only one bolt for easy reorientation.

18. The cabinet shall come with a three-stage, multi-ply progressive density polyester, disposable air filter; and the filter performance shall conform to listed UL 900 Class 2 and shall conform to ASHRAE Standard 52.1. The filter element shall be attached with Velcro type mounting along the full length of all four edges.
19. The door shall be mounted with a single continuous stainless steel piano hinge that runs the length of the door. Attaching tamper resistant bolts shall also be stainless steel.

**Shelves**
The cabinet shall be provided with two (2) double beveled shelves 10” deep that are reinforced welded with V channel, fabricated from 5052-H32 0.125-inch thick aluminum with double flanged edges rolled front to back. Slotted hole shall be inserted every 7” for the purpose of tying off wire bundles.

**Ventilating Fans**
The cabinet shall be provided with a finger safe din rail mounted thermostatically controlled (adjustable between 4-176° Fahrenheit) ventilation fan. The fan shall be installed in the top right side of the cabinet plenum. A removable aluminum vent cover shall be supplied to allow a second thermostatically controlled fan to be added per customer request.

**Computer Shelf**
A slide-out computer shelf 16” length by 12” width by 2” depth shall be installed underneath the lower equipment shelf. The shelf shall be mounted so that controller cables will not interfere with the operation of the shelf when equipment is installed. The shelf shall have a hinged cover that opens from the front and shall be powder-coated black. It shall be a General Devices Part # VC4080-99-1168.

**Main Panel Configuration (Load-Bay)**
**NEMA P and P+ Cabinet**
The design of the panel shall conform to NEMA TS2 Section 5, Terminals and Facilities, unless modified herein. This panel shall be the termination point for the controller unit (CU) MSA, B & C and (MMU) MSA & B cables. The terminal and facilities layout shall be arranged in a manner that allows all equipment to be readily accessible.

The load-bay shall be fully wired and meet the following requirements:
- The load-bay shall have the following dimensions; constructed from aluminum with a nominal thickness of 0.125 inches and a maximum width of 37-½ inches (31.5” for P+) including attached wiring bundles.
- It shall be a Z type configuration.
- The entire assembly shall roll down and provide access to all of the back of panel wiring. All solder terminals shall be accessible when the load-bay is rolled down. The assembly shall be able to roll down without requiring other components, cables or switches to be removed.
- The load-bay shall be designed so that all other cabinet screw terminals are accessible without removing cabinet electronics.
- All the controller (CU) and malfunction management (MMU) cables shall be routed through the back of the load-bay so that they will not be subject to damage during load-bay roll down.
• The top of the load-bay panel shall attach directly to Unistrut™ spring nuts without the use of standoffs and spacers.
• The load-bay shall be balanced such that it will not roll down when fully loaded with load switches, flashers and flash transfer relays, and the Unistrut™ spring nuts are removed.
• The P cabinet shall be designed for 16 channel operation where load switch sockets 1-8 will be configured for a vehicle phase, load switch sockets 9-12 will be pedestrian phase and load switch sockets 13-16 will be overlaps A-D. These load switch sockets shall be configured in this manor without rewiring the back side of the load-bay. Load-bay channels 1-8 and 13-16 shall be routed through a flash transfer relay.
• Sixteen load sockets spaced on 2” center per NEMA TS2 section 5.3.1.2, figure 5-2.
• SIX flash transfer relay sockets.
• One flasher socket.
• All load switches and flasher shall be supported by a bracket extending at least ½ the length of the load switch.
• A screw terminal shall be provided to access all functions on all BIUs.
• Wiring for one Type-16 MMU.
• All 24 VDC relays shall have the same base socket but different from the 115VAC relays.
• All 115VAC relays shall have the same base socket but different from the 24VDC relays. (not applicable to flash transfer relays or the mercury contactor)
• The load-bay shall be silkscreened on both sides.
• Field wiring terminations shall be per channel across the bottom of the load-bay. Each channel shall have 3 terminations from left to right beginning with phase 1 corresponding to the appropriate vehicle phase Red, Yellow and Green and following the order of the load switches. Field terminals shall be #10 screw terminal and be rated for 600V.
• All cable wires shall be terminated. No tie-off of unused terminals will be allowed.
• Shall be 100% manufactured in the United States of America

NEMA M Cabinet
The design of the panel shall conform to NEMA TS2 Type 2 Section 5, Terminals and Facilities, unless modified herein. This panel shall be the termination point for the controller unit (CU) MSA & B & C and (MMU) MSA & B cables. The terminal and facilities layout shall be arranged in a manner that allows all equipment in the cabinet and all screw terminals to be readily accessible by maintenance personnel.

The load-bay shall be fully wired and meet the following requirements:
• The load-bay shall have the following dimensions; constructed from aluminum with a nominal thickness of 0.125 inches and a maximum width of 17 ¼ inches including attached wiring bundles.
• The entire assembly shall roll down and provide access to all of the back of panel wiring. All solder terminals shall be accessible when the load-bay is rolled down.
The assembly shall be able to roll down without requiring other components, cables or switches to be removed.

- The load-bay shall be designed so that all other cabinet screw terminals are accessible without removing cabinet electronics.
- All the controller (CU) and malfunction management (MMU) cables shall be routed through the back of the load-bay so that they will not be subject to damage during load-bay roll down.
- The top of the load-bay panel shall attach directly to Unistrut™ spring nuts without the use of standoffs and spacers.
- The load-bay shall be balanced such that it will not roll down when fully loaded with load switches, flashers and flash transfer relays, and the Unistrut™ spring nuts are removed.
- The M cabinet shall be designed for 9 channel operation. Load switches 1-4 shall be vehicle phases 2,4,6,8; load switches 5-8 shall be pedestrian phases 2,4,6,8. Load switch 9 shall be Overlap A. These load switch sockets shall be configured in this manner without rewiring the back side of the load-bay.
- Nine Load sockets spaced on 2” center per NEMA TS2 section 5.3.1.2, figure 5-2.
- Three Flash transfer relay sockets.
- (1) Flasher socket.
- All load switches and flasher shall be supported by a bracket extending at least ½ the length of the load switch.
- Wiring for one Type-16 MMU. All MMU wiring shall be soldered to backside of a screw terminal. The screw terminals provide access to all functions of the MMU.
- All 24 VDC relays shall have the same base socket, but it shall be different from the 115VAC relays.
- All 115VAC relays shall have the same base socket, but it shall be different from the 24VDC relays. (not applicable to flash transfer relays)
- Shall have a relay that drops +24VDC to load switches when the cabinet is in flash.
- The load bay shall have terminals to access the flash circuits 1 and 2.
- There shall be a wire between the pedestrian yellow field terminals and another terminal on the load bay. The MMU channel 9-12 yellows shall terminate next to said pedestrian yellows terminal.
- The load-bay shall be silkscreened on both sides, numbers and functions on the front side, and numbers only on the back side.
- Field wiring terminations shall be per channel across the bottom of the load-bay. Each channel shall have 3 terminations corresponding to the appropriate vehicle phase Red, Yellow and Green. Default wiring shall be left to right vehicle phases 2, 4, 6, 8, pedestrian phases 2, 4, 6, 8 and Overlap A, following the order of the load switches. Field terminals shall be #10 screw terminal and be rated for 600V.
- All cable wires shall be terminated. No tie-off of unused terminals will be allowed.
- Shall be 100% manufactured in the United States of America

**NEMA P, P+ and M Cabinets**

**Wiring**
All wiring shall conform to NEMA TS2 Type 2 section 5.2.5 and table 5-1. Conductors shall conform to military specification MIL-W-16878D, Electrical insulated high heat wire, type B. Conductors #14 or larger shall be permitted to be UL type THHN. Main panel wiring shall conform to the following colors and minimum wire sizes:

- Vehicle green load switch output: 14 gauge brown
- Vehicle yellow load switch output: 14 gauge yellow
- Vehicle red load switch output: 14 gauge red
- Pedestrian Don’t Walk switch: 14 gauge orange
- Pedestrian Walk switch: 14 gauge blue
- Pedestrian Clearance load switch: 14 gauge yellow
- Vehicle green load switch input: 22 gauge brown
- Vehicle yellow load switch input: 22 gauge yellow
- Vehicle red load switch input: 22 gauge red
- Pedestrian Don’t Walk input: 22 gauge orange
- Pedestrian Walk input: 22 gauge blue
- Pedestrian Clearance input: 22 gauge yellow

- Logic Ground: 18 gauge gray
- +24V DC: 18 gauge red with white tracer
- +12V DC: 18 gauge pink
- AC+ Line: 14 gauge black
- AC- Line: 14 gauge white
- Earth Ground: 16 gauge green

- AC line (load bay): 12/14 gauge black
- AC neutral (load bay): 12/14 gauge white
- Controller A, B and C cables: 22 gauge blue with the exception of power wires (AC+ Black, AC- White & Earth Ground Green)

- MMU A & B cables: 22 gauge orange with the exception of power wires (AC+ Black, AC- White & Earth Ground Green)

The field terminal blocks shall have a screw Type No. 10 post capable of accepting no less than 3 No. 12 AWG wires fitted with spade connectors. Four (4) 12-position terminal blocks shall be provided in a single row across the bottom of the main panel. Spade lugs from internal cabinet wiring are not allowed on field terminal screws. The flash program shall be changeable from the front of the load-bay. All load switches, flasher, and flash transfer relay sockets shall be marked and mounted with screws. Rivets and clip-mouting is unacceptable.

Wire size 16 AWG or smaller at solder joints shall be hooked or looped around the eyelet or terminal block post prior to soldering to ensure circuit integrity. All wires shall have lugs or terminal fittings when not soldered. Lap joint/tack on soldering is not acceptable. All soldered connections shall be made with 60/40 solder and non-corrosive, non-
conductive flux. All wiring shall be run neatly and shall use mechanical clamps and conductors shall not be spliced between terminations. Cables shall be sleeved in braided nylon mesh and wires shall not be exposed.

**Load-Bay and Panel Wire Termination**
All wires terminated behind the main panel or on the back side of other panels shall be SOLDERED. No pressure or solder-less connectors shall be used.

**Cabinet Light Assembly**
The cabinet shall have an LED lighting fixture with 15 high power LEDs using a cool white color emitting 300Im min @ 12VDC/750mA. The LED shall be a Rodeo Electronics TS-LED-05M02 or equivalent. The LED fixture shall be powered by a Mean Well class 2 power supply LPV-20-12 that shall be mounted on the inside top of the cabinet near the front edge. The cabinet light circuit shall be designed so a second LED fixture can be installed in the cabinet without the need a of a second power supply. An on/off switch that is turned on when the cabinet door is opened and off when it is closed shall activate the lighting fixture(s) power supply.

**Convenience Outlet**
The cabinet shall be wired with one convenience outlet with a ground fault interrupter and TWO power strips without ground fault interrupters. The ground fault outlet shall be mounted on the right side of the cabinet on or near the power panel. The power strips shall be...on each side above...the top shelf. No outlets shall be mounted on the door. The GFI power shall be fed through the auxiliary breaker. The power strip shall be fed through an EDCO SHP300-10 transient voltage suppressor located on the cabinet power panel. There shall be a 2-position terminal block on the power panel, between the power strip and the EDCO SHP300-10 for easy replacement.

**9-29.16 Vehicular Signal Heads, Displays, and Housings**
*(October 1, 2017  COS GSP)*

*Replace* the second paragraph with the following:

Backplates shall be constructed of 5-inch-wide, .050-inch-thick corrosion-resistant flat black finish, be non-louvered, and be one-piece. Backplates shall be supplied with a 2 inch wide yellow (#3931) Type 4 High Intensity Prismatic retroreflective sheeting installed on the perimeter.

**9-29.17 Signal Head Mounting Brackets and Fittings**
*(August 1, 2008  COS GSP)*

*Delete* the last paragraph.

**9-29.24 Service Cabinets**
*(November 1, 2012  COS GSP)*

*Replace* this Section in its entirety with the following:
All electrical conductors, buss bars, and conductor terminals shall be copper.

The minimum size of control circuit conductors used in service cabinets shall be 14 AWG stranded copper with THWN insulation.

Service cabinets shall be constructed of steel or aluminum. If aluminum, they shall be fabricated from 0.125 inch (minimum) and anodized. If steel, they shall be fabricated from 12-gauge (minimum) steel, and hot dipped galvanized.

Doors shall be lockable with a padlock.

**Aerial Service Cabinet**

The aerial AC service enclosure shall be Square D model QO2-4L70RB or an approved equal meeting the following:

The AC service enclosure shall be lockable, rain-tight, designed for two large 60 amp circuit breakers expandable to four small circuit breakers, rated at 70 amps, and suitable for mast mounting.

The enclosure for the AC service shall be designed so that the access door to the circuit breakers may be opened without de-energizing either the controller branch service or the street lighting branch service.

The AC service shall be designed so that the street lighting branch circuit and the controller branch circuit may be separately de-energized.

**Ground Mounted Service Cabinet**

The ground mounted service cabinet with underground service entrance shall be a Tesco Model 26-100 or an approved equal:

The Cabinet shall be UL listed.

The cabinet shall be fabricated from 12 gauge, hot dipped galvanized steel, or 1/8 inch anodized aluminum, or 304D 14 gage stainless steel as required, and be rated as a NEMA 3R enclosure.

The internal parts shall be fabricated from 14 gage cold rolled steel.

The cabinet shall be of all welded construction with welding materials specifically designed for the material used.

All fasteners, hinges, latches, and hardware shall be of stainless steel and hinges shall be continuous piano type.

There shall be no exposed nuts, bolts, screws, rivets or other fasteners on the exterior.

The cabinet shall have a fully framed side hinged outer door with swaged close tolerance sides for flush fit with top drip lip and closed cell neoprene flange compressed gaskets.

The cabinet door shall have a 2,000 pound stress rated hasp, welded to the cabinet door. 4- 5/8 inch x 18 inch anchor bolts and applicable appurtenances (including nuts) shall be provided.
The distribution and control panel shall have a hinged deadfront panel with 1/4 turn latch and knurled knobs. The deadfront shall be hinged on the same side as the front door and shall open a minimum of 120°. The unit shall contain a removable back panel.

**Power Distribution Panel**

It shall provide separate main and disconnects- as required. All circuit breakers shall be installed in a vertical position, handle up for "On", handle down for "Off". All circuit breakers shall be industrial grade, plug-in breakers shall not be used. All bushings shall be UL approved THHN cable busing, fully rated for 125 Amps. At least 6 standard single pole circuit breakers spaces (3/4 inch nominal) shall be provided.

**Control Compartment**

The cabinet shall be completely prewired in the factory. All terminals shall be permanently labeled. All control wiring shall be #14 AWG THHN.

Replace this section in its entirety with the following:

**9-29.25 Terminal Cabinets**

*(April 1, 2018  COS GSP)*

Terminal cabinets shall be NEMA 3R and meet the following specifications:

1. Cabinets shall be constructed of 0.125 inch thick 5052-H32 aluminum using continuously welded construction.
2. Nominal cabinet dimensions shall be 8”d x 16”h x 12”w.
3. Cabinet doors shall have a full length, heavy gauge, stainless steel piano hinge.
4. All cabinets shall have a double flanged door with a closed cell neoprene door gasket.
5. Includes a drip shield.
6. Cabinet shall include 2 – 12 position Insulated terminal blocks (Marathon 1512DJ) The blocks shall be 600 volt, heavy-duty, barrier type. The terminal blocks shall be provided with a field-side and a control-side connector separated by a marker strip.
7. Main door lock is a Best CX series Green core lock with latch type locking bolt.
8. Mounting shall be as noted in the Contract.

Add the following new Section:

**9-29.100 Pre Formed Loops**

*(June 22, 2018  COS GSP)*

Preformed Loops shall:

Preformed Loops shall:

Contain 16 AWG or 14 AWG stranded copper wire with THHN insulation.
Consist of the number of turns according to the Standard plans or as detailed on the plan sheets.
Constructed with an outer protective duct of 5/8” (outside diameter) hydraulic hose and be injected with rubberized asphalt.
Contain no splices.
Lead-ins shall contain a minimum twist of the loop wire of 3 twists per foot.
Be factory tested and provided with factory test report indicating wire continuity and loop inductance.

Loop sealant for use in HMA pavement shall be one of the following:

QCM EAS – 14 Epoxy Adhesive
RAI Pro-Seal 6006 Ex
CRAFCO 34271 (hot pour)
3M 5000 (cold sealant)
Fields T Series – Type T4 (hot pour)

Loop sealant for use on concrete bridge decks and PCC pavement shall be one of the following:

AHT 1614JFR – HP Joint Sealant (hot pour)
QCM EAS – 14 Epoxy Adhesive
RAI Pro-Seal 6006 Ex
3M 5000 (cold sealant)

Hot loop sealants shall be heated according to the manufacturer’s recommendations.

Backer rod shall not shrink when exposed to hot pour sealants. The Contractor shall demonstrate this in the field prior to installation.

The Contractor shall submit catalog cuts of the preformed loop, sealant, and backer rod for review and approval by the Street Department.

Add the following new Section:
9-29.101 Magnetometers
(November 1, 2014 COS GSP)

Microloop Probes. The microloop probe shall be a cylindrical unit designed to be buried beneath the road surface. The device shall transform magnetic field intensity changes into inductance changes. The device when connected to an inductive loop detector shall detect vehicles containing significant ferromagnetic material.

The probe shall be approximately 0.88-inches in diameter and 3.63-inches long. The lead-in cable shall be factory installed, with a length sufficient to connect to other probes and to the junction box where the lead-in will be spliced to the home-run cable. The entire assembly shall be sealed against moisture entry.
The probe shall have a nominal inductance of 25 microhenries per probe plus 21 microhenries per 100-feet of interconnecting and lead-in cable. The sensitivity shall be 3.5 to 8.0 nanohenries per millioerstads at 50 KHz, 400 millioerstads ambient magnetic field intensity.

Microloop probes shall be furnished and installed as shown on the Plans and on the COS Standard Plans in the ‘J’ series. The Contractor shall measure the vertical component of the magnetic field intensity prior to installation of the microloop probe(s). The location must have a field intensity of between 0.2 Oerstad and 0.8 Oerstad. The Engineer will determine the alternate location if the planned location is not suitable.

Each probe shall be installed vertically in PVC sleeves. The interconnecting cable and lead-in cable shall be installed in a sawcut to the junction box. The microloop lead-in cable shall be spliced into the home run lead-in cable in accordance with the COS Standard Plans in the ‘J’ series.

Add the following new Section:

9-29.102 Non-Intrusive Vehicle Detection System
(April 1, 2018 COS GSP)

The following preapproved non-intrusive vehicle detection system shall be used:

GRIDSMART®:
• GRIDSMART® Bell Camera with ultra-wide angle fisheye camera
• GRIDSMART® Bell Camera mounting bracket
• GRIDSMART® GS2 Processor with TS2 SDLC connector kit and Performance module software included.

Add the following new Section:

9-29.104 Fiber Optic Patch Cords
(November 1, 2014 COS GSP)

Fiber Optic Patch Cords
Fiber optic patch cords shall utilize singlemode fiber, OFNR rated, ceramic ferules, factory connectorized utilizing thermal cured epoxy, UPC polish, with an ORL of -50 dB and maximum insertion loss of 0.5 dB, and consist of tight buffered cable with a 3 millimeter outer jacket. Duplex patch cables shall contain a clip that allows polarity correction of the connectors without the need for special tools. Hybrid patch cords shall be constructed with differing connector types for each end, according to the plans, for connecting devices to patch panels.

Add the following new Section:

9-29.105 Fiber Optic Connectors
(November 1, 2014 COS GSP)
**Fiber Optic Connectors**

Unless otherwise noted in the Plans, fiber optic connectors used on this project shall meet the following:

All fiber optic connectors shall be factory connectorized and polished to UPC with an ORL of -50dB. The connectors shall be of the type specified in the Plans.

All fiber optic connectors shall have a maximum insertion loss of 0.5 dB per connector.

All fiber optic connectors shall be capped with a protective dust cover.

The Contractor shall submit catalog cuts with the Request for Approval of Material for review and approval by the Project Engineer.

Add the following new Section:

**9-29.106  Fiber Optic Splice Closures**

(November 1, 2014  COS GSP)

**Fiber Optic Splice Closures**

Underground Fiber Optic Splice Closure

All underground splice closures shall be COYOTE RUNT or appropriately sized COYOTE DOME.

Traffic Signal Cabinet and VMS Control Cabinet Fiber Optic Splice Closures

All splice closures for Traffic Signal Cabinets and VMS Control Cabins shall be SPH-01P by Corning Cable Systems.

Communication Closet Splice Closures

Splices closures shall be compatible with Siemon patch panel and be contained in the patch panel. Due to space limitations, splice closures that consume rack space below a patch panel will be rejected.

Add the following new Section:

**9-29.107  Fiber Optic Patch Panels**

(November 1, 2014  COS GSP)

**Fiber Optic Patch Panels**

Each patch panel shall be populated with interconnection sleeves according to the Plans. Empty patch panel slots shall have a blank cover. All interconnection sleeves shall have a protective dust cover installed.

The splice trays and the fiber optic interconnection sleeves shall be enclosed on all sides by the patch panel when the patch panel is closed.

Rack Mount Fiber Optic Patch Panels for Aggregate Points
Rack-mount fiber optic patch panels shall be capable of mounting in a standard 19 inch EIA equipment mounting rack. Rack-mount patch panels shall be Siemon.

Rack Mount Fiber Optic Patch Panels for VMS Cabinets
Rack-mount fiber optic patch panels installed in VMS cabinets shall be Siemon, 1 rack unit tall and be capable of mounting in a standard fixed 19 inch EIA equipment rack. Interconnection sleeves shall be mounted to the front of the panel and be Siemon quick pack or equivalent.

Wall Mount Fiber Optic Patch Panels for Traffic Signal Cabinets
Wall mount fiber optic patch panels shall be corning SPH-01P.

Add the following new Section:
9-29.108  Racks and Cable Management
(November 1, 2014  COS GSP)

Racks
Equipment mounting racks in buildings shall be Siemon RS-07-S.

Cable Management
Vertical cable managers shall be Siemon RS-CNL. Horizontal cable managers shall be Siemon WM-143-5, or WM-144-5, or WM-145-5, as noted in the plans.

Add the following new Section:
9-29.109  Video & Data Transmission and Distribution Systems
(November 1, 2014  COS GSP)

General
If any equipment specified in this section has been superseded by a newer product that is interchangeable, the newer product shall be supplied. If the product is no longer available and has no replacement, the Contractor shall propose a different product meeting the same performance and material specifications as the discontinued one.

Equipment
• Ethernet switching devices shall be by Cisco Industries

Manufacturer:
Cisco Systems Inc.
170 West Tasman Dr.
San Jose, CA 95134
Telephone: 1-800-553-6387

Equipment Model Numbers:
- IE 3000 Switch 8TC 10/100 + 2 T/SFP
- IE 3000 Power transformer
- IE 3000 Rack Mount Adapter
- 1000Mbps Single Mode Rugged SFP LX
- Catalyst 3850 12 Port GE SFP IP Services
  - North America AC Type Power Cable
  - 350W AC Config 1 Secondary Power Supply
  - Cisco Cataylyst 3850 4 x 1GE Network Module
  - CAT3850 Universal k9 image
  - 50CM Type 1 Stacking Cable
  - Catylyst 3750X and 3850 Stack Power Cable 30CM
  - 350 W AC Config 1 Power Supply
- 1000BASE-LX/LH SFP transceiver module

The Contractor shall submit catalog cuts with the Request for Approval of Material for review and approval by the Project Engineer.

Add the following new Section:

**9-29.110 Closed Circuit Television Systems**

(August 1, 2015 COS GSP)

**General**
If any equipment specified in this section has been superseded by a newer product that is interchangeable, the newer product shall be supplied. If the product is no longer available and has no replacement, the Contractor shall propose a different product meeting the same performance and material specifications as the discontinued one.

**Television Camera Assembly**
Television cameras shall be supplied as a unit including pan and tilt mechanism, clear lens, and 28 foot pig tail.

1. Equipment Model Numbers:

   Camera: Spectra HD dome drive 30x 1080P D5230P
   Back Box: Spectra IV PENDT MT BB4-PR-E
   Dome: Spectra III PPRES DOME PEND CLR LD53PR-1
   Pressurized back Box Modification SMR-1-252IP7
   Adapter pole mount PA3512
   Modify pole mount with internal channel SMR 1-2FMFAR
   28 ft Pigtail SMR 1-2NOHJV
   Power Supply WCS1-4

2. Manufacturer:

   Pelco
The Contractor shall submit catalog cuts with the Request for Approval of Material prior to ordering this material for review and approval by the Project Engineer.

**CCTV System Cabling**
The Contractor shall terminate power cables to the terminal strip and make necessary connections to the power surge suppressor and camera power supply.

Category 6 cable shall be terminated to an RJ-45 connector for connection to the Ethernet surge suppressor.

The Contractor shall terminate the 28 foot camera cable pigtail to the RJ-45 surge suppressor and the camera power supply.

**Surge Suppression**
Signal/Camera Cabinet surge suppressors shall be Transtector SL-Vor consist of:
- Six NEMA 5-15 outlets.
- Have a nominal operating voltage of 120 VAC.
- Equipped with silicone avalanche suppressor diode technology for over current protection.
- The surge suppressor shall be equipped a visual status indicator for “Operational” or “Fail” conditions.

Surge suppressors isolating the CCTV camera from the Ethernet Switch and between the Signal Controller and the Ethernet Switch shall be Transtector TSJ 10/100BT or consist of:
- Silicone Avalanche Diode Technology
- One in and one out RJ 45 connection
- Maximum of 12 V peak operating voltage
- -30° to +65° C operating environmental temperature
- 90% relative humidity
- Grounding lug

The surge suppressor isolating the CCTV power supply from the Signal Cabinet shall be Transtector ACP100MN.

**NEMA 3R Enclosure**
The enclosure shall be 16” X 12” X 6” painted gray and rated as a NEMA 3R enclosure.

The enclosure shall contain an 8 position terminal strip capable of accepting spade type connectors and an 8 position grounding bus.

The door shall have a continuous vertically oriented piano hinge.
The Ethernet surge suppressor, the line voltage surge suppressor, and the camera power supply shall be mounted in the enclosure.

**Add** the following new Section:

**9-29.111 Permanent Variable Message Sign**

(August 1, 2015 COS GSP)

The VMS display shall be model VF-2420-27 x 110-46A. The VMS display and model 336 pole mounted cabinet shall be supplied by:

Daktronics, Inc,
331 32nd Ave,
Brookings, SD  57006-5128
Phone: (800)
FAX: (605) 697-4300
Email: sales@daktronics.com

The Contractor shall submit catalog cuts with the Request for Approval of Material for review and approval by the Engineer.

**Sign Mounting Hardware**

The sign housing shall be provided with all necessary hardware including sign mounting beams, vertical and horizontal brackets, and all related hardware to install the VMS onto a truss cantilevered sign structure.

The VMS housing, structural framing, face covering, and mounting members shall be designed to withstand a wind velocity of 100 mph with a 30 percent gust factor and shall otherwise comply with the 2001 requirements of AASHTO’s Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

**Circuit Boards**

The manufacturer’s submittal shall include a schematic diagram for each type of circuit board used in the sign display and control system.

**Display LEDs**

LEDs used in the VMS display shall be from one LED manufacturer and of one part number. LEDs shall conform to the following minimum requirements:

1. Operating temperature range shall be -40° C to +100° C, and storage temperature range shall be -40° C to + 100°C.
2. Minimum half power viewing angle shall be 30°. Half power viewing angle is defined such that, at a given distance from the LED, luminous intensity measured at any point at an angle of 15° from the LEDs center axis shall be no less than half the luminous intensity measured directly on the LEDs center axis.
LED Intensity Control System
The VMS shall be equipped with an LED intensity control system. The control shall support both manual and automatic control. LED intensity control shall consist of photo sensors and associated circuitry. VMS controller analysis of these ambient light measurements shall automatically determine which preprogrammed LED intensity levels will provide the best VMS legibility for the given ambient light condition. The LED intensity control system shall not cause flickering of the LED display.

Power Supplies
The LED hybrid display matrix shall be powered by regulated switching DC power supplies that operate from 120 VAC input power and have an output of 24 volts DC or less. Power supplies shall be wired in a redundant parallel configuration that uses multiple supplies per display. The supplies shall have a “current sharing capability that allows them to provide equal amounts of current to their portion of the LED Display. Power supplies shall be rated such that if one supply fails, the remaining supplies will be able to operate their portion of the display under full load conditions (all pixels on at maximum drive current) while in an ambient temperature of +60° C.

Power supplies shall operate within a minimum input voltage range of +90 to +135 VAC. Power supply output at an ambient temperature of +60° C shall be no less than 65% of its room temperature (+21° C) output. Power supply efficiency shall be a minimum of 74%. Power supplies shall have a minimum power factor rating of 0.95. Power supplies shall be short circuit protected. Under short circuit conditions, the DC side of the power supply shall be powered down. The power supplies shall reset automatically after 5 seconds of AS power off. Power supplies shall be protected by a minimum overload allowance of 105%. Inputs to power supplies shall be fused or circuit breaker protected. A failed power supply shall not interfere with the other operating power supplies.

A copy of the power supply manufacturer’s data sheet and its UL or ETL product card shall be provided with the VMS manufacturer’s submittal.

VMS Control Cabinet
The VMS Control Cabinet shall be supplied as a pole mountable 336 style NEMA 3R cabinet as shown in the plans. The mounting bracket shall be tapered to offset the taper of the sign structure allowing the cabinet to be mounted plumb.

The Cabinet shall be constructed of 5052-H34 Aluminum with continuously welded external seams.

The access doors shall contain a three-point latch with stainless steel handle, one per side for two sides. The doors shall be sealed with 0.5” x 2” closed-cell neoprene gaskets. Lock cores shall be City of Spokane specification M-2 “Best” brand, from Allied Fire & Security located in Spokane Washington.

VMS Cabinet Uninterruptable Power Supply
The VMS Cabinet shall be supplied with an Uninterruptable Power Supply that is mounted in the standard EIA 19” rack.

The UPS shall be capable of being managed over the existing Ethernet network.

The batteries shall be leak proof, Maintenance-free Lead –Acid with suspended electrolyte.

Transient Current Protection
VMS and sign controller signal and power inputs shall be protected from electrical spikes and transients.

AC power for all equipment shall be protected at the load center inside the field cabinet. A parallel-connection surge suppresser, rated for a minimum surge of 10 kJ, shall be connected to the load center in a manner that protects the load center and the equipment it feeds.

AC power for control equipment, such as the field controller and communication equipment, shall be further protected by the use of a series-connected surge suppresser capable of passing 15 Amps of current. This device shall be UL 1149 recognized.

EIA 232/485 communications ports in the sign controller shall be protected by avalanche diodes rated for 11.5 volts at 10 Amps and 14 Volts at 70 Amps. The diodes shall be connected between each signal line and ground.

Digital input and output lines from the VMS to the control equipment shall be protected at the control equipment by optically isolated input and output modules, or optically isolated solid state relays. Inputs shall include, but shall not be limited to the VMS regulated power supply diagnostics and the AC power failure alarm. Outputs shall include, but shall not be limited to the cooling fan and defog/defrost fan control.

Sign Controller
The sign controller shall cause the desired message to be displayed on the VMS. The sign shall display alphanumeric character fonts. The sign controller shall be NTCIP compliant and provide a default value for each NTCIP object supported.

Message Selection
With the sign controller software, the central computer or laptop computer shall be capable of implementing a message selected from those stored in controller memory, or a new message entered via the communication port.

A message shall remain displayed on the sign until either a command to change the current message or a command to blank the display is received.

Data Transmission Requirements
Sign Controllers shall have an integrated RJ45 10/100 Base-T Ethernet communication port, an integrated Hayes compatible RJ11 modem port, 3 integrated RS-232 ports, and an integrated RS422 port.

Memory
Sign controllers shall have non-volatile changeable memory capable of retaining data for a minimum of 30 days following a power failure. The memory shall be capable of storing up to 500 changeable messages.

Power Interruptions
Contents of the sign controller’s memory shall be preserved by battery backup during AC power interruptions and the controller shall automatically resume operation once AC power is restored. Upon recovering from a power interruption, the sign controller shall display the message identified by the Power Recovery Message parameter. The sign controller shall report to the central computer that it has recovered from a power interruption.

Control Software
The Contractor shall supply one copy of the Vanguard v4 Standard software. The control software shall be designed to operate on Microsoft Windows 7 operating systems as a minimum.

The software shall be capable of controlling the new VMS and other existing VMS currently controlled from the Spokane Regional Traffic Management Center.

The sign control software shall be a stand alone Personal Computer (PC) application that allows access up to 255 signs through a direct line or dial up connection.

The control software shall provide for command and control of the following functions:

VMS Control
Software shall retrieve, display, update and download/upload the following functional parameters to the local sign controller in response to user-initiated instructions. The pixel service test shall activate every pixel by reversing the image (positive to negative and visa versa) being displayed on the sign at the time of the test, so that the message remains readable. Software shall perform the following operations in conjunction with its monitoring and logging functions:

Display message
Blank the current message
Change message priority
Pixel, lamp and fan tests
Set time and date in the sign controller
Retrieve sign ID, type, and manufacturer

Communications
Communications between the control software and sign controller shall be NTCIP compliant.

The control software shall verify all communications for errors. If a response from a sign controller contains a communications error, or if there is no response the Control Software shall re-establish communications.

Data Collection
The control software shall retrieve errors detected, message number currently being displayed, and current message priority. Using different commands, the software shall retrieve message MULTI strings, a map of defective pixels, the time and date, the event schedule, and configuration parameters.

Message Library
The control software shall store messages and transfer messages to a sign for storage and/or display. When a user desires to send a message to a sign, the control software shall offer as choices only those messages compatible with the sign in question. The control software shall allow message names in plain text representation (no MULTI).

The control software shall display all character fonts supported by the Variable Message Sign System. Message shall be displayed on the computer monitor in exactly the same format (font, text centering and justification) as on the Variable Message Sign.

Software Duplication Rights
The City of Spokane shall have the right to duplicate the Variable message Sign Control Software as needed for use in controlling sings under its jurisdiction.

The Contractor shall supply one copy of the Vanguard v4 Professional and one server license to the City for installation on an existing server.

Documentation
The Contractor shall furnish two paper copies of the Control software user manuals, the sign controller cabinet schematic, and the VMS display cabinet wiring schematic, to the Engineer. In addition the Contractor shall provide two CD ROM disks with the same documents in electronic format to the Engineer.
END OF SECTION 329600
SECTION 331000 – WATER UTILITIES

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 water-distribution piping and related components outside the building for both domestic-water and fire-suppression piping.

B. Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

1.3 DEFINITIONS

A. DI: Ductile iron.

B. HDPE: High density polyethylene plastic.

C. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions.

C. Field quality-control test reports: Indicate and interpret test results for compliance with performance requirements.

D. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:
1. Comply with standards and requirements of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.

2. Comply with standards and requirements of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

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

C. 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.

D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.

E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

G. NSF Compliance:

1. Comply with NSF 14 for plastic potable-water-service piping. Include marking "NSF-pw" on piping.

2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.

2. Protect valves against damage to threaded ends and flange faces.

3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.

2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping 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.
E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:

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

B. Site Information: Field verify existing conditions, research public utility records, and locate existing utilities. Verify the location and size of existing water lines before proceeding with construction activities, including points of connection and utility crossings. Notify the Architect of any discrepancies prior to proceeding.

1.8 COORDINATION

A. Coordinate connection to water main with authority having jurisdiction.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

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

1. Copper Fittings:

   a. NPS 1-1/2 (DN 40) and Smaller: Flared fittings or approved compression fittings.

2.2 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
2.3 HDPE PIPE AND FITTINGS

A. HDPE, AWWA Pipe: AWWA C901, DR No. 9; with PE compound number required to give pressure rating not less than 200 psig (1380 kPa).

1. HDPE, AWWA Fittings: AWWA C901, copper compression fittings and stainless steel stiffeners, with DR number matching pipe and PE compound number required to give pressure rating not less than 200 psig (1380 kPa).

2.4 PVC PIPE AND FITTINGS

A. PVC, AWWA Pipe: AWWA C900, Class 200, with bell end with gasket, and with spigot end.

1. Comply with UL 1285 for fire-service mains if indicated.
2. PVC Fabricated Fittings: AWWA C900, Class 200, with bell-and-spigot or double-bell ends. Include elastomeric gasket in each bell.
3. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
4. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
   a. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.5 JOINING MATERIALS

A. Joining materials: For each type of pipe, use joining materials recommended by piping system manufacturer, unless otherwise indicated.

B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.6 PIPING SPECIALTIES

A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.7 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Nonrising-Stem, Resilient-Seated Gate Valves:
   a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.
1) Standard: AWWA C509.
2) Minimum Pressure Rating: 200 psig (1380 kPa).
3) End Connections: Mechanical joint.
4) Interior Coating: Complying with AWWA C550.

B. UL/FMG, Indicator Post Gate Valves:

1. UL/FMG, Indicator Post, Nonrising-Stem Gate Valves:
   a. Description: Iron body and bonnet with flange for indicator post, bronze mounted, solid-wedge disc, and nonrising stem with operating nut and flanged ends.
      1) Standards: UL 262 and FMG approved.
      2) Minimum pressure rating: 200 psig (1380 kPa).

2.8 GATE VALVE ACCESSORIES AND SPECIALTIES

A. Tapping-Sleeve Assemblies:

1. Description: Sleeve and valve compatible with drilling machine.
   a. Tapping sleeves shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, tapping sleeves shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

B. Valve Boxes: Install valve boxes complete with appurtenances and accessories indicated. Install valve boxes according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, valve boxes shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

C. Indicator Posts: UL 789, FMG-approved, vertical post-type, cast-iron body with operating wrench, windows for target plates that indicate valve position, extension rod and coupling, locking device, red enamel finish, and adjustable cast-iron barrel of length required for depth of burial of valve.

2.9 CHECK VALVES

A. UL/FMG, Check Valves:

1. Description: Swing-check type with pressure rating; rubber-face checks, unless otherwise indicated; and ends matching piping.
   a. Standards: UL 312 and FMG approved.
   b. Minimum Pressure Rating: 200 psig (1380 kPa).
2.10 CORPORATION VALVES AND CURB VALVES

A. Service-Saddle Assemblies: Comply with AWWA C800. Include saddle and valve compatible with tapping machine.

1. Service Saddle: Copper alloy with seal and AWWA C800, threaded outlet for corporation valve.
2. Corporation Valve: Bronze body and ground-key plug, with AWWA C800, threaded inlet and outlet matching service piping material.
3. Manifold: Copper fitting with two to four inlets as required, with ends matching corporation valves and outlet matching service piping material.

B. Curb Valves: Comply with AWWA C800. Include bronze body, ground-key plug or ball, and wide tee head, with inlet and outlet matching service piping material.

C. Service Boxes for Curb Valves: Install service boxes for curb valves complete with appurtenances and accessories indicated. Install service boxes for curb valves according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, service boxes for curb valves shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

2.11 WATER METERS

A. Water meters will be furnished by the authority having jurisdiction. Coordinate requirements with the governing agency.

2.12 BACKFLOW PREVENTERS

A. Double-Check, Backflow-Prevention Assemblies:

1. Standard: AWWA C510, State approved, and subject to compliance with the requirements and standards of the authorities having jurisdiction.
2. Operation: Continuous-pressure applications, unless otherwise indicated.

B. Double-Check, Detector-Assembly Backflow Preventers:

1. Standards: ASSE 1048 and UL listed or FMG approved, State approved, and subject to compliance with the requirements and standards of the authorities having jurisdiction.
2. Operation: Continuous-pressure applications.

2.13 WATER METER BOXES

A. Description: Water meter boxes shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, water meter boxes shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the

2.14 CONCRETE VAULTS

A. Description: Concrete vaults shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, concrete vaults shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

2.15 FIRE HYDRANTS

A. Dry-Barrel Fire Hydrants:

1. Description: Freestanding, with one pumper nozzle to match connection requirements of authorities having jurisdiction and fire department, two NPS 2-1/2 (DN 65) hose nozzles, 5-1/4-inch (133-mm) minimum main valve, drain valve, and NPS 6 (DN 150) mechanical-joint inlet. Include interior coating according to AWWA C550. Hydrant shall have cast-iron body with compression-type valve, opening against pressure and closing with pressure.
   a. Standard: AWWA C502
   b. Pressure Rating: 200 psig (1380 kPa) minimum
   c. Exterior Finish: Two coats of paint, red alkyd-gloss enamel, unless otherwise directed by the authorities having jurisdiction or fire department.

2.16 FIRE DEPARTMENT CONNECTIONS

A. Fire Department Connections:

1. Description: Exposed, freestanding, with cast-brass body, thread inlets according to NFPA 1963 and matching local fire department hose sizes and threads, and threaded bottom outlet. Include brass lugged caps, gaskets, and chains; brass lugged swivel connection and drop clapper for each hose-connection inlet; and round escutcheon plate.
   b. Connections: Comply with governing fire department requirements.
   c. Inlet Alignment: Comply with governing fire department requirements.
   d. Finish Including Sleeve: Rough chrome-plated.
   e. Escutcheon Plate Marking: "AUTO SPKR & STANDPIPE."

PART 3 - EXECUTION

3.1 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
3.2 PIPING APPLICATIONS

A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.

B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

C. Underground water-service piping NPS 3/4 to NPS 3 (DN 20 to DN 80) shall be any of the following:
   1. Soft copper tube, ASTM B 88, Type K; copper, flared fittings or approved compression fittings.
   2. HDPE, AWWA Pipe; copper compression fittings and stainless steel stiffeners.

D. Underground water-service and fire-service piping NPS 4 to NPS 12 (DN 100 to DN 300) shall be any of the following:
   1. Ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings; and mechanical joints.
   2. PVC, AWWA Class 200 pipe; PVC, AWWA Class 200 fabricated fittings push-on-joint, ductile-iron fittings; mechanical-joint, ductile-iron fittings; and gasketed joints.

3.3 VALVE APPLICATIONS

A. General Application: Use mechanical-joint-end valves for NPS 3 (DN 80) and larger underground installation. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 (DN 50) and smaller installation.

B. Drawings indicate valve types to be used.

3.4 PIPING INSTALLATION

A. Water-Main Connection: Arrange with authorities having jurisdiction or utility company for tap of size and in location indicated in water main. Coordinate requirements with authorities having jurisdiction.

B. Comply with NFPA 24 for fire-service-main piping materials and installation.

D. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.

E. Install copper tube and fittings according to CDA's "Copper Tube Handbook."

F. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

G. Install HDPE pipe according to ASTM D 2774 and ASTM F 645.

H. Install PVC, AWWA pipe according to ASTM F 645 and AWWA M23.
I. Bury piping with depth of cover in compliance with requirements of the authorities having jurisdiction.

J. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.

   1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.

K. Install underground piping with restrained joints at horizontal and vertical changes in direction. Restraintment shall comply with the requirements of the authorities having jurisdiction.

3.5 JOINT CONSTRUCTION

   A. Make pipe joints according to the following:

      1. Copper-Tubing, Joints: Use procedure recommended by manufacturer.
      4. HDPE Piping Joints: Use fittings and fasteners according to fitting manufacturer's written instructions.
      5. PVC Piping Gasketed Joints: Use joining materials according to AWWA C900. Construct joints with elastomeric seals and lubricant according to ASTM D 2774 or ASTM D 3139 and pipe manufacturer's written instructions.
      6. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

3.6 ANCHORAGE INSTALLATION

   A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types shall comply with the requirements of the authorities having jurisdiction.

   B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

      2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.

3.7 VALVE INSTALLATION

   A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.

   B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.

D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.

E. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.8 DETECTOR-CHECK VALVE INSTALLATION

A. Install according to requirements of authorities having jurisdiction.

B. Install for proper direction of flow.

C. Support detector check valves, meters, shutoff valves, and piping on brick or concrete pads according to requirements of authorities having jurisdiction.

3.9 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to requirements of authorities having jurisdiction.

B. Water Meters: Install water meters in meter boxes or meter vaults according to size complete with shut off valves, appurtenances, and accessories in accordance with the requirements of the authorities having jurisdiction.

3.10 ROUGHING-IN FOR WATER METERS

A. Rough-in piping and specialties for water meter installation according to requirements of authorities having jurisdiction.

3.11 BACKFLOW PREVENTER INSTALLATION

A. Install backflow preventers of type, size, and capacity indicated. Include valves and required appurtenances. Install according to requirements of plumbing and health department and authorities having jurisdiction.

B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.

C. Do not install bypass piping around backflow preventers.

D. Support NPS 2-1/2 (DN 65) and larger backflow preventers, valves, and piping on brick or concrete pads according to requirements of authorities having jurisdiction.
3.12 WATER METER BOX INSTALLATION
   A. Install water meter boxes in paved areas flush with surface. Water meter boxes shall be suitable for traffic loading.
   B. Install water meter boxes in grass or earth areas with top 2 inches (50 mm) above surface.

3.13 WATER METER VAULT INSTALLATION
   A. Install precast concrete vaults according to ASTM C 891.
   B. Install water meter vaults in paved areas with vault access cover flush with surface. Water meter vaults shall be suitable for traffic loading.
   C. Install water meter vaults in grass or earth areas with vault access cover 2 inches (50 mm) above surface.

3.14 FIRE HYDRANT INSTALLATION
   A. General: Install each fire hydrant with separate gate valve in supply pipe, anchor with restraints according to the requirements of the authorities having jurisdiction, and support in upright position.
   B. AWWA Fire Hydrants: Comply with AWWA M17.
   C. UL/FMG Fire Hydrants: Comply with NFPA 24.

3.15 FIRE DEPARTMENT CONNECTION INSTALLATION
   A. Install ball drip valves at each check valve for fire department connection to mains.

3.16 PROTECTIVE PIPE BOLLARDS
   A. Install protective pipe bollards around each fire department connection and fire hydrant subject to vehicular traffic.

3.17 CONNECTIONS
   A. Drawings indicate general arrangement of piping, fittings, and specialties.
   B. Connect water-distribution piping to existing water system according to requirements of the authorities having jurisdiction.
   C. Connect water-distribution piping to interior domestic water and fire-suppression piping.
3.18 FIELD QUALITY CONTROL

A. Piping Tests: Conduct piping tests before joints are covered and after restraints have been constructed. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.

B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours. Test water system according to requirements of the authorities having jurisdiction and the following.

1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Reconstruct leaking joints with new materials and repeat test until leakage is within allowed limits.

C. Prepare reports of testing activities.

3.19 IDENTIFICATION

A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving."

3.20 CLEANING

A. Clean and disinfect water-distribution piping as follows:

1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.

2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:

   a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.

   b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.

   c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.

   d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.

B. Prepare reports of purging and disinfecting activities.

END OF SECTION 331000
SECTION 333000 – SANITARY SEWERAGE UTILITIES

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 gravity-flow, nonpressure sanitary sewerage beginning 5 feet outside the building, with the following components:
   1. Cleanouts.
   2. Precast concrete manholes.

B. Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: At least equal to system test pressure in conformance with authorities having jurisdiction requirements.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

B. Shop Drawings: Include plans, elevations, and details for the following.
   1. Precast concrete manholes, including frames and covers.

C. Field quality-control test reports: Indicate and interpret test results for compliance with performance requirements.
1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic structures, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle precast concrete manholes and other structures according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:

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

B. Site Information: Field verify existing conditions, research public utility records, and locate existing utilities. Verify the location, elevation, size, and direction of flow of existing sewer lines before proceeding with construction activities, including points of connection and utility crossings. Notify the Architect of any discrepancies prior to proceeding.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.2 PVC PIPE AND FITTINGS

A. PVC Sewer Pipe and Fittings, NPS 15 (DN 375) and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.3 NONPRESSURE-TYPE PIPE COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

2.4 CLEANOUTS

A. Cleanouts: Cleanouts shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, cleanouts shall comply with the most current edition of the Standard Specifications for Road,
Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

2.5 MANHOLES

A. Standard Precast Concrete Manholes: Manholes shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, manholes shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING APPLICATIONS

A. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated. Use when required to join piping and no other appropriate method is specified.

B. Gravity-Flow, Nonpressure Sewer Piping: Use the following pipe materials for each size range:

1. NPS 4 through NPS 15 (DN 100 through DN 375): PVC sewer pipe and fittings, gaskets, and gasketed joints.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into existing sewer is indicated.
D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.

F. Install gravity-flow, nonpressure, drainage piping according to the following:
   1. Install piping pitched down in direction of flow, at minimum slope of 2 percent, unless otherwise indicated.
   2. Install piping with 36-inch (915-mm) minimum cover.
   3. Install piping below frost line.
   4. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.4 PIPE JOINT CONSTRUCTION

A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. Join gravity-flow, nonpressure, drainage piping according to the following:
   1. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.
   2. Join dissimilar pipe materials with nonpressure-type, flexible couplings.

3.5 MANHOLE INSTALLATION

A. General: Install manholes complete with appurtenances and accessories indicated. Install manholes according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, manholes shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Form continuous concrete channels and benches between inlets and outlet.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere, unless otherwise indicated.

3.6 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318/318R.
3.7 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Install cleanouts complete with appurtenances and accessories indicated. Install cleanouts according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, cleanouts shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

B. Set cleanout frames and covers in earth with tops 1 inch (25 mm) above surrounding grade.

C. Set cleanout frames and covers in pavement with tops flush with pavement surface.

3.8 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains.

B. Make connections to existing piping and manholes.
   1. Make connections according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, make connections according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.
   2. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.9 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
   1. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.10 FIELD QUALITY CONTROL

A. Inspect and test sanitary sewerage according to requirements of authorities having jurisdiction.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.
   1. Submit separate report for each system inspection.
   2. Defects requiring correction include the following:
a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
   a. Allowable leakage is maximum of 50 gal./inch of nominal pipe size per mile (4.6 L/millimeter of nominal pipe size per kilometer) of pipe, during 24-hour period.
   b. Close openings in system and fill with water.
   c. Purge air and refill with water.
   d. Disconnect water supply.
   e. Test and inspect joints for leaks.
6. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and according to UNI-B-6.
7. Manholes: Perform hydraulic test according to ASTM C 969 (ASTM C 969M).

D. Leaks and loss in test pressure constitute defects that must be repaired.
E. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.11 CLEANING

A. Clean interior of piping of dirt and superfluous material.

END OF SECTION 333000
SECTION 334000 - STORM DRAINAGE UTILITIES

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 gravity-flow, nonpressure storm drainage outside the building, with the following components:
   1. Cleanouts.
   2. Drains.
   3. Precast concrete catch basins, inlets, and manholes.
   4. Precast concrete drywells.
B. Work and materials shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, work and materials shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

1.3 DEFINITIONS
A. PE: Polyethylene plastic.
B. PVC: Polyvinyl chloride plastic.
C. CPPA: Corrugated Polyethylene Pipe Association.

1.4 PERFORMANCE REQUIREMENTS
A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: At least equal to system test pressure in conformance with authorities having jurisdiction requirements. Pipe joints shall be at least soiltight, unless otherwise indicated.

1.5 SUBMITTALS
A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
B. Shop Drawings: For the following:
   1. Manholes: Include plans, elevations, sections, details, and frames and covers.
   2. Catch Basins and Drywells: Include plans, elevations, sections, details, and frames, covers, and grates.

C. Field quality-control test reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic structures, pipe, and fittings in direct sunlight.

B. Protect pipe, pipe fittings, and seals from dirt and damage.

C. Handle manholes and other structures according to manufacturer's written rigging instructions.

D. Handle catch basins and inlets according to manufacturer's written rigging instructions.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect no fewer than two days in advance of proposed interruption of service.
   2. Do not proceed with interruption of service without Architect's written permission.

B. Site Information: Field verify existing conditions, research public records, and locate existing utilities.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.

2.2 PE PIPE AND FITTINGS

A. Corrugated PE Drainage Pipe and Fittings NPS 10 (DN 250) and Smaller: AASHTO M 252M, Type S, with smooth waterway for coupling joints.

B. Corrugated PE Pipe and Fittings NPS 12 to NPS 48 (DN 250 to DN 1200): AASHTO M 294M, Type S, with smooth waterway for coupling joints
2.3 PVC PIPE AND FITTINGS
   A. PVC Sewer Pipe and Fittings, NPS 15 (DN 375) and Smaller: ASTM D 3034, SDR 35, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.4 NONPRESSURE-TYPE PIPE COUPLINGS
   A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

2.5 CLEANOUTS
   A. Cleanouts: Cleanouts shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, cleanouts shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

2.6 MANHOLES
   A. Standard Precast Concrete Manholes: Manholes shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, manholes shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

2.7 CATCH BASINS
   A. Standard Precast Concrete Catch Basins: Catch basins shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, catch basins shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

2.8 INLETS
   A. Inlets: Inlets shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, inlets shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.
2.9 DRYWELLS

A. Precast Concrete Drywells: Drywells shall comply with the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, drywells shall comply with the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 PIPING APPLICATIONS

A. Pipe couplings and special pipe fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure drainage piping, unless otherwise indicated. Use where required to join piping and no other appropriate method is specified.

B. Gravity-Flow, Nonpressure Drainage Piping: Use the following pipe materials for each size range:

1. NPS 4 to NPS 48 (DN 100 to DN 1200): Corrugated PE pipe and fittings, soiltight couplings, and coupled joints.
2. NPS 4 to NPS 15 (DN 100 to DN 375): PVC sewer pipe and fittings, gaskets, and gasketed joints.

3.3 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes, catch basins, or other specified drainage structures for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or a combination of both.

F. Install gravity-flow, nonpressure drainage piping according to the following:
   1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
   2. Install piping with 36-inch (915-mm) minimum cover, unless otherwise indicated.
   3. Install PE corrugated sewer piping according to CPPA’s "Recommended Installation Practices for Corrugated Polyethylene Pipe and Fittings."
   4. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

3.4 PIPE JOINT CONSTRUCTION

A. Where specific joint construction is not indicated, follow piping manufacturer's written instructions.

B. Join gravity-flow, nonpressure drainage piping according to the following:
   1. Join corrugated PE piping according to CPPA 100 and the following:
      a. Use soil-tight couplings for Type 2, soil-tight joints.
   2. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric gasket joints.
   3. Join dissimilar pipe materials with non-pressure-type flexible couplings.

3.5 CLEANOUT INSTALLATION

A. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Install cleanouts complete with appurtenances and accessories indicated. Install cleanouts according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, cleanouts shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

B. Set cleanout frames and covers in earth with tops 1 inch (25 mm) above surrounding grade.

C. Set cleanout frames and covers in pavement with tops flush with pavement surface.

3.6 MANHOLE INSTALLATION

A. Install manholes complete with appurtenances and accessories indicated. Install manholes according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, manholes shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal
Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

B. Install precast concrete manhole sections according to ASTM C 891.

C. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere, unless otherwise indicated.

3.7 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

C. Install catch basins complete with appurtenances and accessories indicated. Install catch basins according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, catch basins shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

3.8 DRYWELL INSTALLATION

A. Install drywells complete with appurtenances and accessories indicated. Install drywells according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, drywells shall be installed according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.

3.9 CONCRETE PLACEMENT

A. Place cast-in-place concrete according to ACI 318/318R.

3.10 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping to building's storm building drains.

B. Make connections to drainage piping and structures.

1. Make connections according to the requirements and standards of the authorities having jurisdiction. If a standard is not provided by the authorities having jurisdiction, make connections according to the most current edition of the Standard Specifications for Road, Bridge, and Municipal Construction as jointly promulgated by the Washington State Department of Transportation and the Washington State Chapter of the American Public Works Association.
2. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.11 IDENTIFICATION

A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
   1. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.12 FIELD QUALITY CONTROL

A. Inspect and test storm drainage improvements according to requirements of authorities having jurisdiction.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.
   1. Submit separate reports for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.
   3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
   4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Test completed piping systems according to authorities having jurisdiction.
   3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
   4. Submit separate report for each test.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.
3.13 CLEANING

A. Clean interior of piping of dirt and superfluous materials.

END OF SECTION 334000